GEOGRAPHIC SCOPE, ISOLATING MECHANISMS, AND FIRM PERFORMANCE: ANTECEDENTS AND CONSEQUENCES OF ISOLATING MECHANISMS

BY

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DISSERTATION

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ABSTRACT

In this dissertation, I examine the *antecedents* and *consequences* of isolating mechanisms or the barriers to imitation, focusing on the role of geographic scope of knowledge acquisition. I address the following four questions concerning the antecedents and consequences of isolating mechanisms with data from the semiconductor industry.

The first two questions address antecedents of isolating mechanisms, focusing on *sources* of and the *relationships* among the factors creating isolating mechanisms. The first question asks whether geographic scope of knowledge acquisition or the extent to which a firm acquires knowledge from multiple countries can be an independent source of isolating mechanisms. I posit that geographic scope can be an independent source of isolating mechanisms because embeddedness of knowledge in the multiple layers of nested networks within a country can increase causal ambiguity and uniqueness to those who do not have membership in the networks. On this basis, I maintain that, *independently from* and *jointly with* intrinsic characteristics of knowledge, geographic scope of knowledge acquisition can create isolating mechanisms. Empirical analyses using the accelerated failure-time (AFT) technique corroborate the arguments.

The second question addresses the relationship among the causal factors linked to the creation of isolating mechanisms. I posit that the causal factors that create isolating mechanisms can be equifinal and functionally equivalent in nature. Empirical analyses using the fuzzy set qualitative comparative analysis (QCA) method corroborate the arguments that multiple paths can lead to the creation of isolating mechanisms and, in these paths, causal factors from the two different sources of isolating mechanisms, *intrinsic characteristics of knowledge* and *geographic scope of knowledge acquisition,* can be functionally equivalent.

The remaining two questions address consequences of isolating mechanisms, focusing on the *value appropriation* aspects of geographic scope of knowledge acquisition. The third

question addresses the implications of isolating mechanisms in knowledge flow. I maintain that the negative association found in extant literature between geographic scope and innovation outputs measured as the number of forward citations a patent receives, is due in part to the fact that isolating mechanisms impede the flow of knowledge and prevent others from accessing the knowledge, thus making it difficult to cite. Results of mediating effects analyses corroborate the argument that isolating mechanisms created by geographic scope partially mediate the relationship between geographic scope and innovation outputs.

The fourth question examines the value appropriation aspect of isolating mechanisms. I maintain that a firm would achieve better financial performance out of the economic returns from innovation when its innovative knowledge is protected by isolating mechanisms. I empirically test the moderating effects of isolating mechanisms on the relationship between innovation output and financial performance. The results corroborate the argument. Questions 3 and 4 together show the process of value appropriation: isolating mechanisms created via geographic scope (1) can help firms prevent competitors from accessing their innovative knowledge, and (2) by doing so can help firms capture a larger proportion of economic returns from innovation, thus allowing them to enjoy better financial performance.

This dissertation contributes to the research literature in at least four ways. First, it highlights that a broader range of factors can create isolating mechanisms via multiple ways. Second, it shows that geographic scope can be a source of both *value creation* and *value appropriation*, thus helping firms not only *create* but also *sustain* their competitive advantage. Third, it introduces a new motivation of firm internationalization, the creation of isolating mechanisms to sustain competitive advantage. Lastly, it contributes to our methodological understanding by providing possible issues with forward citation-based measurements for innovation.

Grátias agō tibi propter magnam glóriam tuam

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CHAPTER 1: INTRODUCTION

FOUR QUESTIONS ON ISOLATING MECHANISMS

Creating and sustaining rents resides at the center of strategic management. Creating abnormal rates of return is one of the main focuses of studies of competitive advantage (Porter, 1985) and sustaining the rents has been a topic of many studies in strategic management (Barney, 1991; Caves and Porter, 1977; Mahoney and Pandian, 1992; Peteraf, 1993; Reed and Defillippi, 1990, inter alia), whose main ideas can be boiled down to the concept of isolating mechanisms or barriers to imitation (Lippman and Rumelt, 1982; Rumelt, 1984). Isolating mechanisms as impediments to the flow of knowledge can function as 'barriers to imitation' (Mahoney and Pandian, 1992), which consequently help a firm *sustain* competitive advantage by limiting "the *ex post* equilibration of rents among individual firms" (Rumelt, 1984: 567).[1]

Studies in the extant literature have shed light on important characteristics of factors that result in isolating mechanisms (Knott, 2003; Lippman and Rumelt, 1982; Mahoney and Pandian, 1992; Reed and Defillippi, 1990; Rumelt, 1984; Zander and Kogut, 1995, inter alia). However, they have largely focused on the intrinsic characteristics of knowledge (such as tacitness, complexity, specificity, and originality) that are associated with the creation of isolating mechanisms, ignoring geographic scope of knowledge acquisition or the extent to which a firm acquires knowledge from multiple countries. This is a critical void in the literature, especially in this era of globalization, because geographic scope of knowledge acquisition due to its unique attributes can be an independent source of isolating mechanisms and firms can utilize this source of isolating mechanism to implement strategies to sustain their competitive advantage.

[1] Focusing on the impediments to knowledge flow, discussion in this dissertation does not include isolating mechanisms by government intervention (e.g., patents and trademarks, legal restrictions on entry (Rumelt, 1984; Somaya, 2003)).

In this dissertation, I examine antecedents and consequences of isolating mechanisms, focusing on the role of geographic scope of knowledge acquisition. Employing multiple research methodologies and data from the semiconductor industry, I address the following four questions concerning the antecedents and consequences of isolating mechanisms as illustrated in Figure 1.1.

Question 1: [Antecedent 1] Can firms create isolating mechanisms by acquiring knowledge from multiple countries?

Question 2: [Antecedent 2] What is the relationship among the causal factors creating isolating mechanisms?

Question 3: [Consequence 1] What is the role of isolating mechanisms in influencing knowledge flow and innovation outputs?

Question 4: [Consequence 2] What is the role of isolating mechanisms in determining the relationship between innovation and financial performance?

The first two questions address antecedents of isolating mechanisms, focusing on *sources* of and the *relationships* among the factors creating isolating mechanisms, respectively. The first question asks whether geographic scope of knowledge acquisition or the extent to which a firm acquires knowledge from multiple countries can be an independent source of isolating mechanisms. Addressing this question bears important implications because it would answer whether geographic scope of knowledge acquisition can be a source of *sustaining* as well as *creating* competitive advantage, which would, in turn, introduce a new motivation of firm internationalization, the creation of isolating mechanisms. Extant research literature on isolating mechanisms focuses largely on intrinsic characteristics of knowledge (such as tacitness, complexity, and specificity), ignoring geographic scope as a source of isolating mechanisms. In Chapter 3, I posit that geographic scope can be an independent source of isolating mechanisms

because embeddedness of knowledge in the multiple layers of nested networks within a country can increase causal ambiguity and uniqueness to those who do not have membership in the networks. Employing the accelerated failure-time (AFT) technique (Cox and Oakes, 1984; Kalbfleisch and Prentice, 1980), I test whether geographic scope can create isolating mechanisms *independently from* and *jointly with* intrinsic characteristics of knowledge. Empirical analyses with the accelerated failure-time (AFT) technique corroborate the arguments.

The second question addresses the relationship among the causal factors from the two different sources of isolating mechanisms advanced in Question 1. Extant literature suggests the existence of multiple paths (or equifinality) leading to creation of isolating mechanisms. In this regard, answering this question would provide important implications because the existence of multiple paths would imply that firms with different characteristics can implement different types of isolating strategies to achieve the same goal of sustaining their competitive advantage. In Chapter 4, I examine configurational nature of the causal factors linked to creation of isolating mechanisms employing the fuzzy set qualitative comparative analysis (QCA) method (Fiss, 2007; Ragin, 2000, 2008). Empirical analyses corroborate the main thesis of the research study that multiple paths can lead to creation of isolating mechanisms and, in these paths, causal factors from the two different sources of isolating mechanisms advanced in Question 1, *intrinsic characteristics of knowledge* and *geographic scope of knowledge acquisition,* can be functionally equivalent.

The remaining two questions address consequences of isolating mechanisms, focusing on the value appropriation aspect of geographic scope of knowledge acquisition. More specifically, on the basis of the arguments advanced in Questions 1 and 2 that geographic scope of knowledge acquisition can create isolating mechanisms, I address Questions 3 and 4 in Chapter 5 as a process of value appropriation. I maintain that isolating mechanisms created via geographic

scope of knowledge acquisition (1) can help firms prevent competitors from accessing their innovative knowledge, and (2) by doing so can help firms capture a larger proportion of economic returns from innovation, thus helping them enjoy better financial performance. The third question addresses the implications of isolating mechanisms created by geographic scope in influencing knowledge flow and thus innovation outputs. As barriers to imitation, isolating mechanisms impede the flow of knowledge and thus prevent other firms from accessing the innovative knowledge. I submit that analyses on the relationship between geographic scope of knowledge acquisition and innovation outputs, measured as the number of forward citations a patent receives, should incorporate the influences of isolating mechanisms created by geographic scope because geographic scope as an independent source of isolating mechanisms can impede flow of knowledge thus making it difficult to cite patents despite the intension of the would-be citing firms. On the basis of the arguments advanced in Questions 1 and 2 that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms, I maintain that a part of the negative association found in extant literature between geographic scope and innovation quality measured as the number of forward citations a patent receives is due to the fact that isolating mechanisms impede the flow of knowledge and prevent others from accessing the knowledge, thus making it difficult to cite. Empirical analyses with analytical techniques for meditating effects (Baron and Kenny, 1986; MacKinnon, 2008; Shaver, 2005) corroborate the argument that isolating mechanisms created by geographic scope of knowledge acquisition partially mediate the relationship between geographic scope and innovation quality.

The fourth question examines the value appropriation aspect of isolating mechanisms. I maintain that a firm would achieve better financial performance out of the economic returns from innovation when its innovative knowledge is protected by isolating mechanisms. I empirically test the *moderating* effects of isolating mechanisms on the relationship between innovation

output and financial performance. The results of empirical analyses corroborate the main argument.

I empirically test the four questions with patent and firm-level data in the semiconductor industry. Studies have shown that patent citations can be a good proxy for measuring the flow of knowledge. Patent citations show the trails of new knowledge creation (Singh, 2005) because "a citation of Patent X by Patent Y means that X represents a piece of previously existing knowledge upon which Y builds" (Jaffe, Trajtenberg, and Henderson, 1993: 580), even after controlling for the spurious citations (Jaffe, Fogarty, and Banks, 1998). As such, patent citations data can provide rich information on isolating mechanisms by allowing us to capture the extent to which knowledge flow has been impeded. I also employ firm-level performance and control variables to test Question 4. The industry context is appropriate to investigate the four questions because first the semiconductor industry is a representative high-tech industry with rapid technological progress and a well-established global standard and presence (Almeida, 1996; Breznitz, 2007; Henisz and Macher, 2004; Ziedonis, 2004) and second it controls for possible influences from industry structure (Ahuja, Lampert, and Tandon, 2008). Empirical findings generally support the main thesis of the dissertation that geographic scope of knowledge acquisition is an independent source of isolating mechanisms; multiple combinations of causal factors can lead to the creation of isolating mechanisms; and geographic scope can be a source of value appropriation by impeding flow of knowledge and thus allowing a focal firm to more exclusively capture the economic returns from innovation.

The theoretical arguments and empirical findings of this dissertation suggest that firms can strategically leverage their geographic scope of knowledge acquisition to better appropriate the economic return from innovation. Question 1 shows that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms. Question 2 shows that firms

with different resources and capabilities can employ different strategies to achieve the same goal of creating isolating mechanisms in such a way that fits best to the existing resources and capabilities of each firm. Questions 3 and 4 illustrate that firms can achieve better financial performance with isolating mechanisms created through geographic scope of knowledge acquisition, which prevent others from accessing their innovative knowledge, thus allowing a longer period of time to more exclusively capture the economic return from innovation. In sum, geographic scope of knowledge acquisition can be a source of both value creation and value appropriation. As such, managers need to implement viable strategies for international knowledge sourcing that fit best to the heterogeneous resources and capabilities of their firms in order to make the most out of their geographic resources and capabilities when creating and appropriating value from their geographic scope of knowledge acquisition.

This dissertation contributes to the research literature in at least four ways. First, it highlights that a broader range of factors can create isolating mechanisms via multiple ways. Second, it shows that geographic scope can be a source of both *value creation* and *value appropriation* and can help firms not only *create* but also *sustain* their competitive advantage. Third, it introduces a new motivation of firm internationalization, the creation of isolating mechanisms to sustain competitive advantage. Lastly, it contributes to our methodological understanding by contrasting implications of linear regressions and the fuzzy set QCA method and providing possible issues with forward citation-based measurements for innovation.

In the following sections, I first briefly review literature on isolating mechanisms and further discuss the four questions with data and methodology employed for empirical analyses. Discussion and conclusions will then follow.

ISOLATING MECHANISMS

Isolating mechanisms result from the rich connection between *causal ambiguity* and *uniqueness* (Lippman and Rumelt, 1982). Causal ambiguity can create isolating mechanisms because it prevents would-be imitators from figuring out the sources of superior performance. Uniqueness can lead to isolating mechanisms because factors are immobile when they are unique. Causal ambiguity has the characteristics of tacitness, complexity, and specificity (Reed and Defillippi, 1990) and uniqueness is associated with factor immobility (Lippman and Rumelt, 1982). In fact, it is the interaction between these two characteristics of the isolating mechanisms that increases the height of the barriers to imitation (Lippman and Rumelt, 1982).

ANTECEDENTS OF ISOLATING MECHANISMS

Questions 1 and 2 for the antecedents concern the *sources* and *relationship* among causal factors leading to creation of isolating mechanisms. Question 1 focuses on the geographic scope of knowledge acquisition as an independent *source* of isolating mechanisms, in addition to the intrinsic characteristics of knowledge. Question 2 then further examines the *relationship* among the causal factors from the two independent sources of isolating mechanisms, focusing on equifinality and functional equivalence.

Question 1: Geographic Scope as an Independent Source of Isolating Mechanisms

The first question concerns the *source* of isolating mechanisms. Causal ambiguity and uniqueness are the factors creating isolating mechanisms (Lippman and Rumelt, 1982; Mahoney and Pandian, 1992; Rumelt, 1984). The extant research literature has largely focused on the intrinsic characteristics of knowledge as a source of causal ambiguity and uniqueness. In Chapter 3, I maintain that *geographic scope of knowledge acquisition* can also be an independent source

of causal ambiguity and uniqueness, as illustrated in Figure 1.1. As established in the literature of national systems of innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993), knowledge is embedded in multiple layers of networks within each country (Granovetter, 1985; Powell, Koput, and Smith-Doerr, 1996), leading to each country possessing a distinct set of knowledge (Malmberg, Sölvell, and Zander, 1996; Sölvell and Zander, 1998). The multiple layers of networks include the networks of physical, human, and social capital (Malmberg *et al.*, 1996). These multiple layers of networks imply that, in addition to the intrinsic characteristics, knowledge can be 'relationship-specific' (Johanson and Vahlne, 2009) and/or reside in 'social capital'[2] (Inkpen and Tsang, 2005; Sölvell and Zander, 1998). These multiple layers of networks could increase the fluidity of knowledge (Sölvell and Zander, 1998) to its members and thus make it easier to flow knowledge to insiders (Johanson and Vahlne, 2009).

Due largely to the embeddedness of knowledge in the networks of a country, outsiders to the relevant networks would suffer from the liability of outsidership (Johanson and Vahlne, 2009) or the liability of unconnectedness (Baum and Oliver, 1992) and thus would find it harder to figure out the overall system in which particular knowledge to be imitated is embedded. This, in turn, could result in a higher degree of information asymmetry and could increase causal ambiguity. Even when the knowledge is not causally ambiguous, it could be difficult for a would-be imitator to extract or separate a certain part of knowledge that is embedded in a system of nested networks and transplant it into another system of nested networks because the knowledge embedded in the network of *relationships* cannot be appropriately "taken out of context without losing much of its value" (Malmberg *et al.*, 1996: 92). In addition, the

[2] This dissertation adopts Inkpen and Tsang's definition of social capital: "..... the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization - a definition that accommodates both the private and public good perspectives of social capital" (Inkpen and Tsang, 2005: 151).

inseparability and non-transplantability are expected to persist because, within a country, "institutions, norms and values become increasingly specialized and unique, adding to the fluidity of knowledge exchange in the local environment and preventing diffusion to the outside" (Sölvell and Zander, 1998: 409). This kind of factor immobility could in turn increase uniqueness.

The foregoing discussion suggests that geographic scope can engender causal ambiguity and uniqueness, *independent from* intrinsic characteristics of knowledge as illustrated in Figure 1.2. First, the main source of causal ambiguity from geographic scope is *information asymmetry* (Arrow, 1974) due to the liabilities of outsidership (Johanson and Vahlne, 2009), while the main source of causal ambiguity arising from intrinsic characteristics of knowledge is tacitness and/or complexity (Reed and Defillippi, 1990). These two sources of causal ambiguity are independent because knowledge that is neither tacit nor complex can be causally ambiguous (Ambrosini and Bowman, 2010; Fabrizio and Thomas, 2012; King and Zeithaml, 2001; Zander and Kogut, 1995), if the would-be imitators suffer from the liability of outsidership and therefore are disadvantaged by information asymmetry because it is the insidership to the network through which firms can learn new knowledge, build trust, develop commitment, and identify opportunities (Johanson and Vahlne, 2009).

Likewise, the main source of uniqueness from geographic scope is *inseparability* and *non-transplantability* of knowledge, while that from intrinsic characteristics of knowledge is specificity and/or originality. These two sources of uniqueness are also independent from each other because knowledge that is not unique to the firms in a country can be unique to firms from other countries because the knowledge embedded in the multiple layers of nested networks of the country can be inseparable and thus non-transplantable or immobile. More specifically, unlike the firms in a country that share the multiple layers of nested networks into which the knowledge to be imitated is embedded, firms from other countries do not share the multiple layers of the

networks and, therefore, may find it difficult to transplant the knowledge into networks of their home countries because the knowledge is unique or specific to the networks of the host country.

For the empirical test of this question, I operationalize the degree of isolation as *the time to the first forward citation* by other firms, which measures the length of time between the patent application and the first forward citation to the patent by other firms. The rationale behind this measure is that it takes longer to cite a patent that is isolated. When a firm creates isolating mechanisms, other firms find it difficult to imitate its knowledge. Although knowledge tends to leak despite the effort to prevent it (Almeida and Kogut, 1999; Jaffe *et al.*, 1993), the rate of leakage would be slower when the knowledge is hard to imitate because the imitation requires much more effort than otherwise. Therefore, an isolating mechanism can manifest itself in the decreased likelihood of imitation and/or the delay in time to imitation (Zander and Kogut, 1995). In other words, if knowledge is difficult to imitate due to isolating mechanisms, it would be less likely for other firms to imitate the knowledge (Hoetker and Agarwal, 2007). Moreover, even though imitated, it will take longer. As such, if a patent contains hard-to-imitate knowledge, then it could take longer for other firms to cite the patent. In order to estimate the effects of covariates on the time to the first citation, I employ an accelerated failure-time (AFT) model (Cox and Oakes, 1984; Kalbfleisch and Prentice, 1980). I specify shared frailty (Gutierrez, 2002; Hougaard, 1984), which is a survival model analog of random effect model to control for unobservable firm level heterogeneity.

The empirical findings with the patent data filed in European Patent Office generally corroborate the main thesis of this research study that, *independently from* and *jointly with* intrinsic characteristics of knowledge, geographic scope can increase overall causal ambiguity and uniqueness of knowledge to be imitated, thus creating isolating mechanisms.

Question 2: Equifinality and Functional Equivalence in Isolating Mechanisms

The second question concerns on the *relationship* among the causal factors creating isolating mechanisms. As advanced in Question 1, intrinsic characteristics of knowledge and geographic scope of knowledge acquisition constitute two independent sources of isolating mechanisms but work together to create isolating mechanisms. Although interaction specifications in the regression models analyzed in Question 1 show some limited number of cases of possible relationship between the causal factors from the two different sources of isolating mechanisms, they are not enough to address a general relationship among the causal factors because of the exponentially increasing number of interaction terms to exhaust all possible combinations of causal factors from the two sources of isolating mechanisms. Therefore, in order to address the following questions on the general relationship among the causal factors, we need a different approach: *In what kind of combinations do they work together? Is it a single combination or multiple combinations that leads to isolating mechanisms? Are the causal factors from the two sources mutually substitutable*? In Chapter 4, I take a different analytical approach to address these questions from that used in Question 1. Answering these questions would provide important strategic implications: given firms are heterogeneous bundles of resources and capabilities (Amit and Schoemaker, 1993), each firm can implement a unique strategy to create isolating mechanisms with different combinations of causal factors that fit best to its existing resources and capabilities.

A review of the extant research literature provides two important implications in terms of the relationship among the causal conditions leading to isolating mechanisms: *equifinality* and *functional equivalence.* First, there can be many causal paths leading to creation of isolating mechanisms. In evolutionary biology, isolating mechanisms are understood as "arranged like a series of hurdles; if one breaks down, another must be overcome" (Mayr, 1970: 66). In this light,

the inter-species gene flow is impeded by multiple series of isolating mechanisms, usually in several pairs. In the management literature, Lippman and Rumelt (1982: 420) maintain that "..... Factors of production cannot become mobile unless they are known ..... factors of production that are immobile not only because they are unique, but also because their replication is a difficult and uncertain endeavor". In fact, it is the interaction between these two characteristics of isolating mechanisms that increases the height of the barriers to imitation. In addition, unlike the implicit assumption in the literature, tacit knowledge may not be a necessary condition for an isolating mechanism (Knott, 2003: 942; Mahoney, 2005: 207). These statements suggest that it is a *configuration* of causal factors rather than a single factor that creates isolating mechanisms. More fundamentally, these statements imply that there exist multiple paths or combinations of causal factors leading to isolating mechanisms, each of which would be sufficient but not necessary to create isolating mechanisms (i.e., equifinality). As the two sources of causal ambiguity and uniqueness, *intrinsic characteristics of knowledge* and *geographic scope of knowledge acquisition*, are independent from each other, we can expect that different combinations of causal factors from each of the two sources of causal ambiguity and uniqueness can lead to creation of isolating mechanisms.

Second, different sources of causal ambiguity and uniqueness can be functionally equivalent (Gresov and Drazin, 1997; Merton, 1967). Given the equifinality of causal factors linked to the creation of isolating mechanisms, causal ambiguity and uniqueness from different sources can play similar roles in creating isolating mechanisms. In this light, causal ambiguity and uniqueness from geographic scope can be functionally equivalent to (or substitute) those from intrinsic characteristics of knowledge because geographic scope can constitute an independent source of causal ambiguity and uniqueness.

For the empirical test of Question 2, I take a set-theoretic approach (Fiss, 2007) to examine the configurational nature of the causal factors creating isolating mechanisms. The set-theoretic approach is appropriate because "These [set-theoretic] methods are premised on the idea that different conditions *combine* rather than compete with each other in creating an outcome and that there may be different combinations of conditions that lead to the same outcome, thus making them well suited for studying configurations and equifinality" (Fiss, 2007: 1183). For this purpose, I employ the fuzzy set qualitative comparative analysis (QCA) (Fiss, 2007; Ragin, 2000, 2008; Schneider, Schulze-Bentrop, and Paunescu, 2010). Unlike standard analytic techniques that are based on the assumptions of *unifinal*, *additive*, and *symmetric* causal relationships, QCA assumes *equifinal*, *conjunctural*, and *asymmetric* causal relationships (Wagemann and Schneider, 2010). In this light, the fuzzy-set QCA would be ideal for studying configurations or interdependence of factors leading to isolating mechanisms (Greckhamer, Misangyi, Elms, and Lacey, 2008) and, thus, provides an ideal analytical tool to address the question.

The empirical analyses with the patent data filed in European Patent Office corroborate the main thesis that the causal factors leading to creation of isolating mechanisms can be equifinal and functionally equivalent in nature. More specifically, it is different types of configuration or combinations of causal factors that creates isolating mechanisms and, among these configurations, causal factors from different sources of *intrinsic characteristics of knowledge* and *geographic scope of knowledge acquisition* can be functionally equivalent, thus being mutually substitutable.

CONSEQUENSES OF ISOLATING MECHANISMS

Questions 3 and 4 for the consequences concern performance implications of isolating mechanisms, focusing on the value appropriation aspects of geographic scope of knowledge

acquisition. In these two questions, I examine that isolating mechanisms can be devices of value appropriation by impeding imitation from competitors. First, isolating mechanisms make it harder for other firms to imitate knowledge of the focal firm by impeding flow of knowledge. By doing so, thus increasing uncertainty of imitation, isolating mechanisms enable firms to prevent their competitors from imitating the newly created knowledge or they delay the time to imitation. In other words, isolating mechanisms help a focal firm exclude its competitors from accessing and utilizing the new knowledge, which consequently allows the firms to enjoy more room to exclusively capture the value created through their innovation activities. In short, isolating mechanisms impede knowledge flow, prevent competitors from imitating, and consequently help a focal firm enjoy more room to exclusively appropriate the econmic returns from innovation by limiting *ex post* competition over the innovation (Peteraf, 1993). Question 3 focuses on the impeded flow of knowlege and Question 4 on financial performance.

Question 3: Isolating Mechanisms and Knowledge Flow

The third question addresses implications of isolating mechanisms on knowledge flow. The main thesis advanced in Questions 1 and 2 is that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms and it can work together with intrinsic characteristics of knowledge in multiple combinations when creating isolating mechanisms. Question 3 investigates consequences of isolating mechanisms as barriers of knowledge flow, focusing on the implications in measuring innovation outputs.

Extant studies acknowledge that geographic scope of knowledge acquisition is a source of *value creation*. Due to the country differences and firm embeddedness, acquiring knowledge from foreign countries could allow a focal firm to access less redundant knowledge and thus provide the focal firm with a higher chance of enjoying unique (re-)combination of knowledge

(Bercovitz and Feldman, 2011; Kogut and Zander, 1992; Schumpeter, 1934). In addition, heterogeneity in international markets can also increase the breadth of knowledge sources, which would in turn enhance the probability of generating valuable innovative outcomes (Leiponen and Helfat, 2010). Therefore, firms acquiring knowledge from a number of countries can enjoy better chance of value creation or innovation than others acquiring solely from domestic markets.

Geographic scope of knowledge acquisition, however, can also be a source of *value appropriation* by impeding flow of knowledge. As advanced in Questions 1 and 2, geographic scope can be an independent source of isolating mechanisms and work together with other causal factors when creating isolating mechanisms. In other words, geographic scope of knowledge acquisition not only helps firms create innovative knowledge but also can impede the flow of the knowledge, thus preventing other firms from accessing the innovative knowledge. In this regard, it is of critical importance to realize that isolating mechanism can *mediate* the influence of geographic scope on innovation outputs measured with the variables that capture the flow of innovative knowledge into other firms. Studies on the relationship between geographic scope and innovation outputs have employed different types of measures for innovation outputs: *the number of patents* (Penner-Hahn and Shaver, 2005) and *the number of forward-citations a patent receives* (Lahiri, 2010; Singh, 2008). Employing the number of forward citations as a proxy to measure the innovation outputs, recent studies show that geographic scope can have a negative association with the quality of innovation performance (Singh, 2008). However, unlike the patent count approach, the forward citation-based approach can be confounded without appropriate consideration for the role of isolating mechanisms because isolating mechanisms created from the geographic scope can have negative influences on forward citations by impeding flow of knowledge: imitators can find it difficult to cite the patents even though the patents are high in quality because isolating mechanisms impede flow of knowledge. In other words, the isolating

mechanisms can *mediate* relationship between the geographic scope and the number of forward citations. Therefore, if the influences of isolating mechanisms created by geographic scope are not explicitly considered, the findings on the negative relationship between geographic scope and the number of forward citations can be confounded with the negative effects on the number of forward citations from the isolating mechanisms as depicted in Figure 1.3.

Empirically, this question addresses whether the effects from isolating mechanisms created by geographic scope of knowledge acquisition *mediate* the relationship between geographic scope and innovation performance. Therefore, I employ a set of tests for mediation effects (Baron and Kenny, 1986; MacKinnon, 2008; Shaver, 2005). In addition, in order to address methodological issues arising from the non-linear nature of the dependent variables in the tests of mediation effects, I employ a quasi-Bayesian Monte Carlo approximation method to estimate causal mediation effects recently suggested by Imai and colleagues (Imai, Keele, and Tingley, 2010a; Imai, Keele, Tingley, and Yamamoto, 2010b, 2011).

Empirical analyses with patent data filed at the US Patent Office support the existence of *partial* mediation by isolating mechanisms on the relationship between geographic scope of knowledge acquisition and the number of forward citations (MacKinnon, 2008: 68-70). This finding corroborates the main argument that geographic scope of knowledge acquisition not only generates innovative knowledge but also creates isolating mechanisms, which impede flow of knowledge and thus prevent other firms from accessing the innovative knowledge. This finding also illuminates that research studies employing innovation outputs measured with forward-citation-based variables (e.g., the number of forward citations a patent receives or the number of patents weighted by the number of forward citations) should pay special attention to possible confounding effects of isolating mechanisms on the innovation outputs.

Question 4: Isolating Mechanisms and Financial Performance

The fourth question highlights the value appropriation aspects of isolating mechanisms. The main thesis advanced in Question 3 highlights that geographic scope of knowledge acquisition can be a source of value appropriation as well as value creation by creating isolating mechanisms. First, isolating mechanisms make it harder for other firms to imitate knowledge of the focal firm by impeding flow of knowledge. Lippman and Rumelt articulate that "uncertain imitability obtains when the creation of new production functions is inherently uncertain and when either causal ambiguity or property rights in unique resources impede imitation and factor mobility" (Lippman and Rumelt, 1982: 421). By impeding the flow of knowledge, thus increasing uncertainty of imitation, isolating mechanisms allow firms to prevent their competitors from accessing the newly created innovative knowledge. In other words, isolating mechanisms help a focal firm exclude its competitors from utilizing the innovative knowledge, which consequently allows the firms to enjoy more room to exclusively capture the value created through their innovation activities. Foss and Foss (2005: 544) expound this point: "Value appropriation presupposes that the owner can *exclude* non-owners from using or destroying attributes to which he holds property right" (italic in the original paper). In short, isolating mechanisms impede knowledge flow, prevent competitors from accessing the innovative knowledge, and consequently help a focal firm enjoy more room to exclusively capture the economic returns from innovation by limiting *ex post* competition over the innovation (Peteraf, 1993).

In this light, isolating mechanisms can provide an effective device to exclusively appropriate the value created through innovation by excluding those who do not have property rights to the innovation. Firms often face difficulties in capturing values they created through innovation due to the nature of knowledge that tends to diffuse (Almeida and Kogut, 1999; Jaffe *et al.*, 1993) and subsequent expropriation by competitors (Liebeskind, 1996; Teece, 1986).

Impeding the flow of knowledge and thus preventing competitors from accessing the innovative knowledge, isolating mechanisms help a focal firm enjoy more room to appropriate and capture a larger proportion of the value it created. In this way, isolating mechanisms can increase the marginal effects of innovation on financial performance as illustrated in Figure 1.3.

Changes in marginal effects of innovation outputs on financial performance across different levels of isolating mechanisms can be tested with specification of an interaction term for moderation effects (Frazier, Tix, and Barron, 2004). Empirical analyses with patent data filed at the US Patent Office and other firm level control variables shows that the interaction term between innovation outputs and isolating mechanisms shows a positive and statistically significant coefficient, corroborating the main thesis of this question that a firm can capture a larger proportion of the economic return from innovation and thus enjoy better financial performance when its innovative knowledge is protected by isolating mechanisms.

Findings in Questions 3 and 4 jointly underscore the value appropriation aspect of geographic scope of knowledge acquisition. Question 3 shows that isolating mechanisms created via geographic scope of knowledge acquisition help firms prevent competitors from accessing their innovative knowledge. Question 4 elucidates that firms can enjoy better financial performance out of given innovation outputs when their innovative knowledge is protected by isolating mechanisms. In fact, each of these two questions illustrates the process of value appropriation. First, Question 3 shows the prerequisite of value appropriation in that "value appropriation presupposes that the owner can *exclude* non-owners from using or destroying attributes to which he holds property right" (Foss and Foss, 2005: 544). Second, Question 4 shows the consequence of the exclusion. By excluding other firms from accessing the innovative knowledge, firms can enjoy room to more exclusively capture the economic returns from

innovation of given quality and thus achieve better financial performance. Through this process, geographic scope of knowledge acquisition can be a source of value appropriation.

DISCUSSION AND CONCLUSION

This dissertation examines antecedents and consequences of isolating mechanisms, focusing on geographic scope of knowledge acquisition. Complementing the extant literature that has largely focused on the intrinsic characteristics of knowledge as a source of isolating mechanisms, this dissertation investigates geographic scope of knowledge acquisition as an independent source of isolating mechanisms and its performance implications. The theoretical framework and empirical findings of this dissertation suggest that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms and firms can appropriate more of their economic returns from innovation by implementing international knowledge acquisition strategies appropriate to their existing resources and capabilities.

This dissertation contributes to the management research literature in at least four ways. First, it highlights that we need to consider a broader range of factors and multiple ways of creating isolating mechanisms. It shows that geographic scope can be *an independent source* of isolating mechanisms, and different strategic recipes or configurations of causal factors can achieve the same goal of creating isolating mechanisms.

Second, it shows that geographic scope can be a source of both value creation and value appropriation, thus helping firms not only *create* but also *sustain* their competitive advantage. It shows that geographic scope, by creating isolating mechanisms around a firm's innovation knowledge, can help a firm sustain its competitive advantage by reducing the ability of competitors to imitate its knowledge. By using geographic scope strategically, a firm can sustain

its competitive advantage even if the resources underlying that advantage would otherwise be difficult to isolate from imitation.

Third, it suggests a new motivation of firm internationalization, beyond *creating* competitive advantage via exploitation/exploration of knowledge as established in the literature. The existing literature maintains that firms internationalize to create value by either exploiting firm-specific advantages in international markets (Dunning, 1988; Hymer, 1960/1976) or seeking new strategic resources in those markets (Makino, Lau, and Yeh, 2002; Moon and Roehl, 2001). This dissertation suggests that internationalization, specifically knowledge acquisition from international markets, can help sustain competitive advantage by leveraging the unique attributes of international markets to create isolation mechanisms.

Lastly, it also contributes to an advance in our methodological understanding. It shows that research studies employing certain types of innovation output measures need to pay special attention to the nature of the measurement. More specifically, studies employing the number of forward citations or the number of patents weighted by the number of forward citations should consider possible mediating effects of isolating mechanisms; otherwise the measures can be confounded.

STRUCTURE OF DISSERTATION

The following chapters are structured as follows: In Chapter 2 briefly reviews literature on isolating mechanisms. Chapter 3 addresses the first question whether geographic scope is an independent source of isolating mechanisms. Chapter 4 examines the second question on the relationship among the causal factors creating isolating mechanisms, focusing on equifinality and functional equivalence. Chapter 5 explores Questions 3 and 4, highlighting the value appropriation aspects of geographic scope. Lastly, Chapter 6 provides discussion and conclusion.

FIGURES AND TABLES

Figure 1.1: Four Questions on Antecedents and Consequences of Isolating Mechanisms

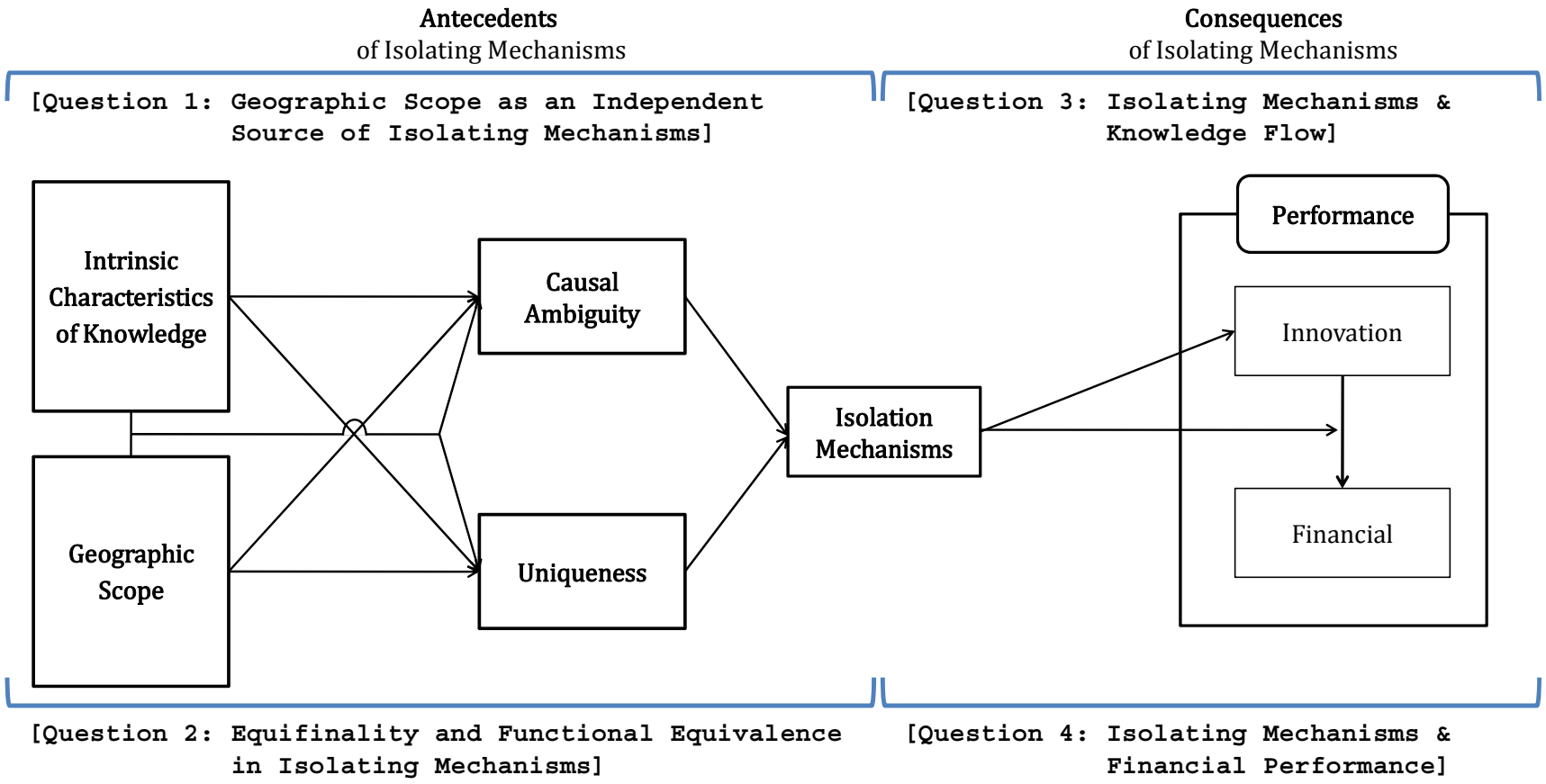


Figure 1.2: Sources of Causal Ambiguity and Uniqueness

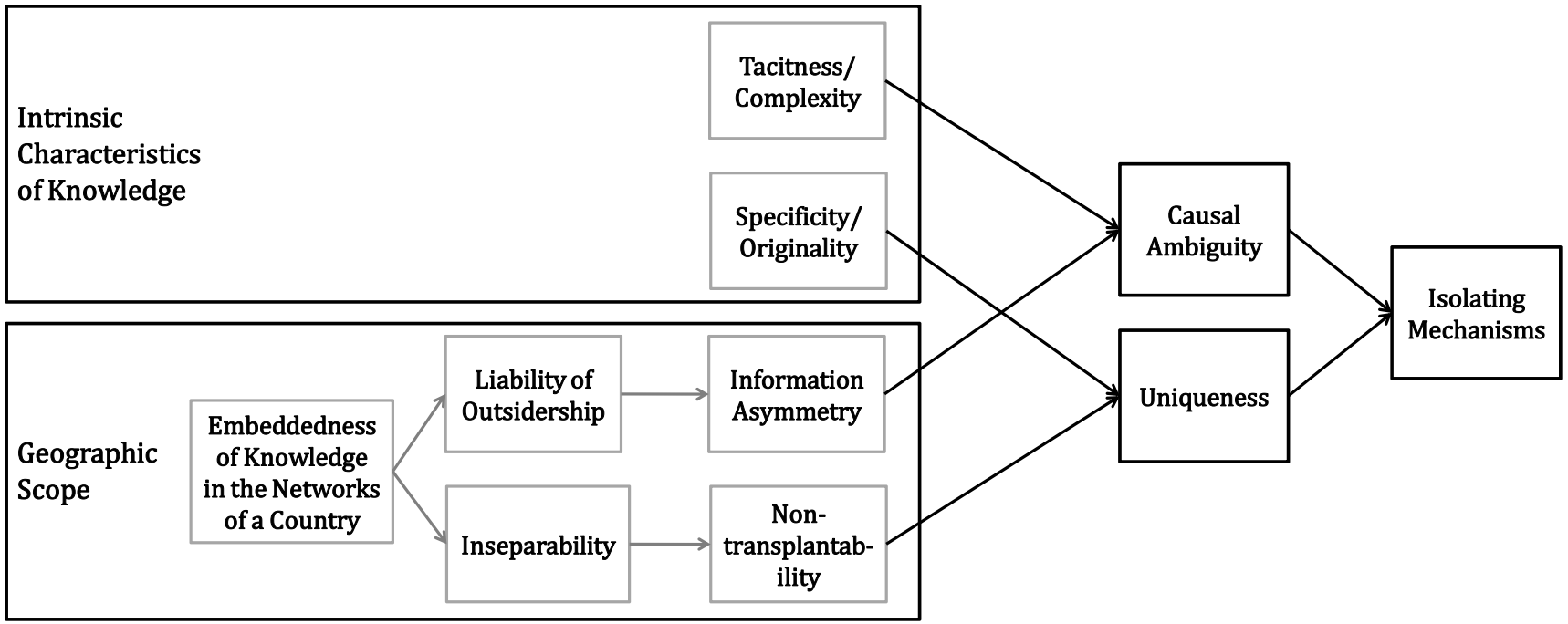
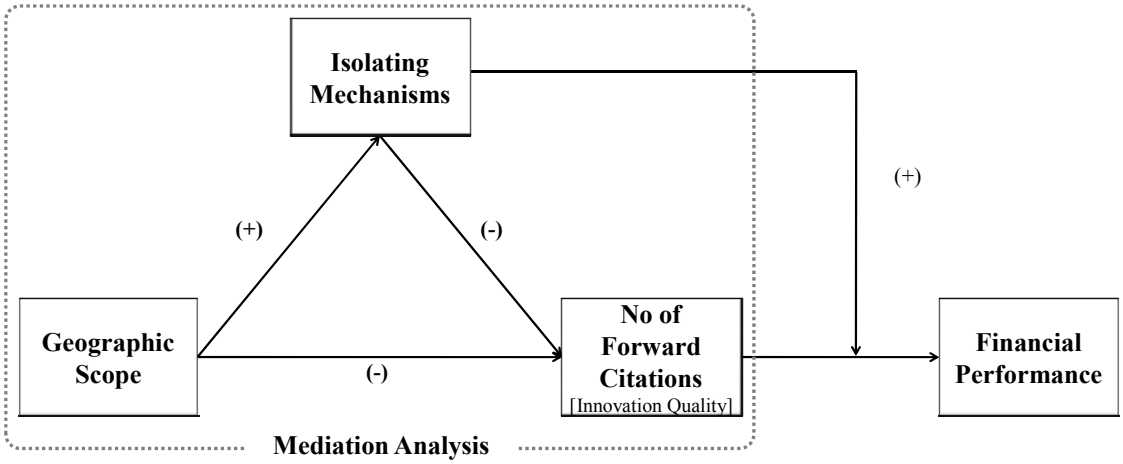


Figure 1.3: Isolating Mechanisms and Value Appropriation



CHAPTER 2: ISOLATING MECHANISMS

ISOLATING MECHANISMS IN EVOLUTIONARY BIOLOGY

The term 'isolating mechanisms' was first introduced by Dobzhansky (1937), an evolutionary biologist. The isolation mechanisms are a collection of reproductive characteristics that prevent species from interbreeding (Dobzhansky, 1937; Mallet, 1998; Mayr, 1970). The isolation mechanisms serve to maintain integrity of specie by impeding the intra-specie gene flow. The mechanisms can be classified into two broad categories according to the stages of mating: *pre-mating* and *post-mating* (Mallet, 1998; Mayr, 1970). The *pre*-mating mechanisms prevent individuals from mating and the *post*-mating mechanisms hinder interbreeding through genomic incompatibility, hybrid inviability, or sterility. The isolating mechanisms are "arranged like a series of hurdles; if one breaks down, another must be overcome" (Mayr, 1970: 66). Therefore, the interbreeding is prevented by multiple series of isolation mechanisms, usually in several pairs. Table 2.1 lists the isolation mechanisms in the sequence of barriers to overcome for successful interbreeding (Mayr, 1970: 56).

ISOLATING MECHANISMS IN STRATEGIC MANAGEMENT

The isolating mechanisms in business contexts refer to 'barriers to imitation' to sustain competitive advantage (Mahoney and Pandian, 1992), or "phenomena that limit the *ex post* equilibration of rents among individual firms" (Rumelt, 1984: 567). The isolating mechanisms result from the rich connection between *uniqueness* and *causal ambiguity* (Lippman and Rumelt, 1982) or existence of *asset-specificity* and *bounded rationality* (Mahoney and Pandian, 1992; Williamson, 1979). The uniqueness is associated with factor immobility (Lippman and Rumelt, 1982) and the causal ambiguity has the characteristics of tacitness, complexity, and specificity

(Reed and Defillippi, 1990). In fact, it is the interaction between these two characteristics of the isolating mechanisms that increases the height of the barriers to imitation. Lippman and Rumelt (1982: 420) provide an insightful perspective on the relationship between the two components of isolating mechanisms:

> Ambiguity as to what factors are responsible for superior (or inferior) performance acts as a powerful block on both imitation and factor mobility ..... it may never be possible to produce a finite unambiguous list of the factors of production responsible for the success of such firms ..... Factors of production cannot become mobile unless they are known ..... factors of production that are immobile not only because they are unique, but also because their replication is a difficult and uncertain endeavor (Lippman and Rumelt, 1982: 420).[3]

In addition to the uniqueness and causal ambiguity, recent studies emphasize that incentives (Knott, 2003) or receptiveness (Cummings and Teng, 2003) plays an important role in implementing isolating mechanisms. In some cases, even explicit knowledge is not adopted due to imitating firms' overconfidence to their existing knowledge (Knott, 2003) and/or receptiveness to learning new knowledge: the imitating firms may have less motivational disposition to acquire knowledge (Gupta and Govindarajan, 2000; Szulanski, 1996) or suffer from not-invented-here syndrome (Katz and Allen, 1982), thus establishing 'self-imposed barriers to imitation' (Knott, 2003). Therefore, tacit knowledge may not be a necessary condition for an isolating mechanism (Mahoney, 2005: 207). Table 2.2 lists major studies on isolating mechanisms.

[3] Caves and Porter (1977) introduce the concept of mobility barriers between strategic groups. But Rumelt maintains that "The group concept is frequently all that is needed, but there is no theoretical reason to limit mobility barriers to groups of firms. I shall therefore use the term *isolating mechanism* to refer to phenomena that limit the *ex post* equilibration of rents among individual firms" (Rumelt, 1984: 567).

An isolating mechanism can manifest itself in the decreased likelihood of imitation and/or the delay in time to imitation (Zander and Kogut, 1995). When a firm creates isolating mechanisms, other firms find it difficult to imitate its knowledge. Although knowledge tends to leak despite efforts to prevent it from doing so (Almeida and Kogut, 1999; Jaffe *et al.*, 1993), the rate of leakage is slower when the knowledge is difficult to imitate because the imitation requires greater efforts than otherwise. Therefore, an isolating mechanism can empirically be detected in the decreased likelihood of imitation and/or the delay in time to imitation. In other words, if knowledge is difficult to imitate due to isolating mechanisms, it would be less likely for other firms to imitate the knowledge (Hoetker and Agarwal, 2007). Moreover, even though imitated, it will take longer. As such, if a patent contains hard-to-imitate knowledge, then it could take a longer period of time for other firms to cite the patent (Zander and Kogut, 1995).

FIGURES AND TABLES

Table 2.1: Classification of Isolation Mechanisms

Classification	Sub-classification	Contents
Pre-mating isolating mechanisms	Temporal isolation	Individuals of different species do not mate because they are active at different times of day or in different seasons.
	Ecological isolation	Individuals mate in their preferred habitat, and therefore do not meet individuals of other species with different ecological preferences.
	Behavioral isolation	Potential mates meet, but choose members of their own species.
	Mechanical isolation	Copulation is attempted, but transfer of sperm does not take place.
Post-mating isolating mechanisms	Gametic incompatibility	Sperm transfer takes place, but egg is not fertilized.
	Zygotic mortality	Egg is fertilized, but zygote does not develop.
	Hybrid inviability	Hybrid embryo forms, but of reduced viability
	Hybrid sterility	Hybrid is viable, but resulting adult is sterile.
	Hybrid breakdown	First generation (F1) hybrids are viable and fertile, but further hybrid generations (F2 and backcrosses) may be inviable or sterile.

Source: Adapted from Mallet (1998)

Table 2.2: Existing Studies on Isolating Mechanisms

Nature and Characteristics leading to Isolation	Major Studies on Isolating Mechanisms				Related Studies
	Lippman and Rumelt (1982)	Rumelt (1984)	Reed and Defillippi (1990)	Mahoney and Pandian (1992)	
Causal Ambiguity	· Causal ambiguity	· Search costs · Causal ambiguity · Team-embodied skills	· Tacitness · Complexity · Specificity	· Bounded rationality	· Firms exit (death) (Hoetker and Agarwal, 2007) · Away from clusters (Shaver and Flyer, 2000) · R&D concentrated in home countries (Rugman, 1981) · Reduction of the scope of the alliance (Oxley and Sampson, 2004) · Natural excludability (Rothaermel and Thursby, 2007)
Uniqueness	· Uniqueness	· Specialized assets · Switching costs · Unique resources · Special information · Reputation and image		· Asset-specificity	· Networking within class: similar size, corporate counterpart, market contact (Greve, 1998) · Exclusivity based on social status (Podolny, 1994) · Investing in relation-specific assets (Kang, Mahoney, and Tan, 2009)

CHAPTER 3: GEOGRAPHIC SCOPE AS AN INDEPENDENT SOURCE OF ISOLATING MECHANISMS

INTRODUCTION

Isolating mechanisms enable a firm to protect its rent-generating resources from duplication or imitation by competitors (Lippman and Rumelt, 1982; Mahoney and Pandian, 1992; Rumelt, 1984).[4] Lippman and Rumelt (1982) posited that isolating mechanisms exist when competitors cannot determine the source of a firm's superior performance (causal ambiguity) or when the resources leading to superior performance are immobile and unique to the firm. Since innovative knowledge is often the source of competitive advantage, much of the existing literature on isolation mechanisms has focused on the intrinsic characteristics of knowledge that engender causal ambiguity and uniqueness, e.g., tacitness and asset-specificity.

This chapter of the dissertation extends this work by focusing on an alternative and independent source of causal ambiguity and uniqueness, the geographic scope of a firm's knowledge acquisition or the extent to which a firm acquires its knowledge from multiple countries. This chapter begins with an observation, which is well established in work on national systems of innovation, that knowledge is embedded in multiple nested networks within each country, leading to each country possessing a distinct set of knowledge (Malmberg *et al.*, 1996; Sölvell and Zander, 1998). The embeddedness of knowledge means that a would-be imitator without membership in the networks may find it difficult to understand the overall system in which the knowledge to be imitated is embedded. This information asymmetry can make ambiguous even knowledge that is not intrinsically so. Even when the knowledge is not causally

[4] Focusing on the impediments to knowledge flow, discussion in this dissertation does not include isolating mechanisms by government intervention (e.g., patents and trademarks, and legal restrictions on entry (Rumelt, 1984; Somaya, 2003)).

ambiguous, a would-be imitator may find it difficult to extract the knowledge from one system of networks and transplant it into another system of networks. This form of factor immobility can make even general knowledge effectively unique. Therefore, this chapter suggests that, *independently from* and *jointly with* intrinsic characteristics of knowledge, geographic scope can increase overall causal ambiguity and uniqueness of knowledge, helping isolate it from imitation.

The empirical findings of the current study support this thesis. Using a large sample of patents from the semiconductor industry, I find that both geographic scope of the knowledge embodied in a patent and the intrinsic nature of that knowledge affect the speed with which others cite that patent. Patents embodying knowledge from more isolated countries and from a larger number of countries are more isolated from imitation, that is, are not cited by other firms, for longer time periods. Similarly, patents embodying knowledge that is intrinsically more unique or causally ambiguous remain un-cited for longer time periods. In addition to these independent effects, the two sources of isolating mechanisms amplify each other's effects.

This research makes at least three primary contributions to the strategic management and international business literatures. First, it suggests a broader range of factors to be considered as sources for isolating mechanisms. Both the intrinsic characteristics of a resource, in our case knowledge, and the nature of its source determine the degree to which it can be isolated from imitation.

Second, this study complements recent work on the role of geographic scope in creating competitive advantage through innovation, primarily through participation in innovative clusters (Lahiri, 2010; Singh, 2008). It shows that geographic scope, by creating isolating mechanisms around a firm's innovation knowledge, can enable a firm to sustain its competitive advantage by reducing the ability of competitors to imitate its knowledge. By using geographic scope

strategically, a firm can sustain its competitive advantage even if the resources underlying that advantage would otherwise be difficult to isolate from imitation.

The third contribution is to introduce a new motivation for firm internationalization by extending this logic to the context of international business. The existing literature maintains that firms internationalize to create value by either exploiting firm-specific advantages in international markets (Dunning, 1988; Hymer, 1960/1976) or seeking new strategic resources in those markets (Makino *et al.*, 2002; Moon and Roehl, 2001). The current research study suggests that internationalization, specifically knowledge acquisition from international markets, can help sustain competitive advantage by leveraging the attributes of international markets to create isolation mechanisms. Firms may be motivated to internationalize their operations and isolate themselves from competitors, thus sustaining their competitive advantages, even when all the resources and capabilities they need are available in their domestic markets and, therefore, there is no need to 'seek' those resources and capabilities in international markets.

THEORY: GEOGRAPHIC SCOPE AS AN ISOLATING MECHANISM

As shown in Table 2.2, main focuses of the extant studies are on intrinsic characteristics of knowledge that engender causal ambiguity and uniqueness, such as tacitness, complexity, specialized assets, and unique resources. The role of geographic scope in creating isolating mechanisms, however, has been neglected in the extant literature.

This section introduces the argument that intrinsic characteristics of knowledge and geographic scope constitute two independent dimensions of causal ambiguity and uniqueness. In other words, causal ambiguity and uniqueness can originate not only from intrinsic characteristics of knowledge but also from the geographic scope because the embeddedness of knowledge into multiple layers of networks in a country can engender causal ambiguity and

uniqueness independently from intrinsic characteristics of the knowledge. In this way, geographic scope can be an independent source of causal ambiguity and uniqueness, thus creating isolating mechanisms. Figure 3.1 illustrates the two dimensions of causal ambiguity and uniqueness.

This section develops the argument of geographic scope as an isolating mechanism in three sub-sections. The first sub-section introduces the embeddedness of knowledge in the networks of a country by joining a conception of a country as a distinctive knowledge set and knowledge in a multiple layers of networks. The next sub-section then develops a mechanism through which the embeddedness of knowledge in the networks of a country can lead to causal ambiguity and uniqueness. The final sub-section introduces the argument that geographic scope can be an independent source of causal ambiguity and uniqueness, contrasting the nature and sources of causal ambiguity and uniqueness engendered via geographic scope and intrinsic characteristics of knowledge.

Embeddedness of Knowledge in the Networks of a Country

Embeddedness of knowledge in the networks of a country is the fundamental factor that renders geographic scope as an independent source of isolating mechanism. This sub-section first discusses a conception of a country as a distinctive knowledge set and then discusses the existence of knowledge in multiple layers of networks. Integration of these two concepts leads to the embeddedness of knowledge in the networks of a country, a main implication of which is that each country provides a minimal set of networks for an independent system of innovation to fully operate.

Country as a Distinctive Knowledge Set

When compared with domestic markets, international markets have two distinctive attributes: *a higher degree of market frictions* and *a higher degree of heterogeneity*. These two attributes of international markets interact to render a country as a distinctive knowledge set.

First, international markets can provide a higher degree of market frictions than domestic markets. Countries differ in cultural, administrative/political, geographic, and economic dimensions (Ghemawat, 2001, 2003, 2007) and, due largely to these differences, firms investing abroad can experience much higher market frictions than those in domestic markets. These market frictions, in turn, give rise to multiple layers of uncertainty (Miller, 1992), information asymmetry (Arrow, 1974), and lack of legitimacy, local knowledge, and relationships in host countries (Chan and Makino, 2007; Zaheer, 1995). This results in additional costs of doing business or liability of foreignness (Dunning, 1998; Hymer, 1960/1976; Teece, 1981b; Vernon, 1966; Zaheer, 1995) and the liabilities of outsidership from relevant networks (Johanson and Vahlne, 2009).

Second, international markets can provide a higher degree of heterogeneity than domestic markets. Firms acquiring knowledge from multiple countries can enjoy greater sources of diverse resources and capabilities than those acquiring only from a single domestic market. Countries differ from each other (Ricart, Enright, Ghemawat, Hart, and Khanna, 2004) in terms of not only factor endowments but also socio-political institutions and cultural aspects (Brouthers, Brouthers, and Werner, 2008; Cheng, 1994; Henisz and Macher, 2004; Kristensen and Zeitlin, 2005). Countries also differ from each other in their technological and organizational principles (Kogut, 1991), patterns of demand (Fabrizio and Thomas, 2012), and systems of innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993). Firms are embedded in the countries of their operation in terms of resources and capabilities (Collis, 1991; Dunning, 1998; Kogut, 1991; Porter, 1990,

1994, 1998; Shan and Hamilton, 1991), historically determined political and economic conditions or institutions (Hamilton and Biggart, 1988), and social relationships (Granovetter, 1985), and therefore, are influenced by the characteristics of the countries' knowledge. In this light, country differences and firm embeddedness provide different types of prior knowledge and, thus, create unique knowledge corridors for the firms operating in a country (Shane, 2000). As such, characteristics of knowledge tend to be relatively more homogeneous among the firms within a country but relatively more heterogeneous among the firms across countries.

Interactions between these two attributes of international markets render a country as a distinctive knowledge set. The higher degree of market frictions in the international markets maintains and reinforces the higher degree of heterogeneity across countries, which would in turn increase market frictions in the international markets. Due largely to its tacit and sticky nature, knowledge is difficult to transfer (Szulanski, 1996; von Hippel, 1994), especially across country borders (Teece, 1977). As such, countries are characterized by accumulated knowledge and capabilities that are different from others in multiple dimensions (Fabrizio and Thomas, 2012; Kogut, 1991; Ricart *et al.*, 2004). These differences would in turn make it harder to diffuse across than within country borders (Kogut, 1991). This process renders countries as distinctive knowledge sets.

Knowledge in Multiple Layers of Networks

Knowledge resides in multiple layers of networks, each of which plays a critical role for particular knowledge to perform its full function: each layer of the network is complementary to each other in the process of creating and transferring knowledge. A locus of innovation is found in the networks of learning (Podolny and Page, 1998; Powell *et al.*, 1996), which resides in the systems of nested networks (Harary and Batell, 1981; Hitt, Beamish, Jackson, and Mathieu, 2007;

Moliterno and Mahony, 2011). These multiple layers of networks include the networks of physical, human, and social capital (Malmberg *et al.*, 1996): in addition to the intrinsic characteristics, knowledge can be 'relationship-specific' (Johanson and Vahlne, 2009) and/or reside in 'social capital'[5] (Inkpen and Tsang, 2005; Sölvell and Zander, 1998). These multiple layers of network could increase the fluidity of knowledge (Sölvell and Zander, 1998). Therefore, knowledge should accompany all the relevant layers of networks in order to perform its full function.

Country as a Minimal Set of Networks

The integration of these two concepts, *a country as a distinctive knowledge set* and *knowledge in multiple layers of networks*, leads to the embeddedness of knowledge in the networks of a country (Granovetter, 1985). First, the conception of countries as distinctive knowledge sets expounds that countries themselves are isolated from each other (Sölvell and Zander, 1998). Second, knowledge in multiple layers of nested networks shows that all the layers of networks in which the knowledge resides should work together for the knowledge to perform its full function. Therefore, layers of networks that are necessary for particular knowledge to perform its function are geographically confined, mostly at the country level (Malmberg *et al.*, 1996).

The main implication of the embeddedness of knowledge in the networks of a country is that each country provides a minimal set of networks for an independent system of innovation to fully operate, in which knowledge is embedded. In other words, a country constitutes a 'least common multiple' of networks that allows an independent system of nested networks (Harary

[5] The current study adopts Inkpen and Tsang's definition of social capital: "..... the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization - a definition that accommodates both the private and public good perspectives of social capital" (Inkpen and Tsang, 2005: 151).

and Batell, 1981; Hitt *et al.*, 2007; Moliterno and Mahony, 2011) to perform its full function. Therefore, in order to fully understand and transfer knowledge of a particular country, firms need to have membership in the country.

Embeddedness of Knowledge as a Source of Causal Ambiguity and Uniqueness

The embeddedness of knowledge in multiple layers of nested networks in a country can engender causal ambiguity and uniqueness to those who do not share the networks. First, outsidership to the relevant networks can lead to causal ambiguity. As a network provides its members with exchange relationship through which they can access knowledge, resources, or markets (Inkpen and Tsang, 2005), outsiders to the relevant networks would suffer from the liability of outsidership (Johanson and Vahlne, 2009) or the liability of un-connectedness (Baum and Oliver, 1992), which could lead to information asymmetry and causal ambiguity. In an update to the original Uppsala internationalization process model (Johanson and Vahlne, 1977), Johanson and Vahlne (2009) postulate that knowledge is created in relationships and view the business environment as a network of the relationships. On this basis, Johanson and Vahlne (2009) maintain that it is the outsidership to this network that is the source of uncertainty and that those who are outside the relevant network would suffer from the liability of outsidership because knowledge is embedded in the network and, therefore, outsiders would suffer from information asymmetry.

Second, embeddedness of knowledge can increase factor immobility and thus create uniqueness. More specifically, due to the embeddedness of knowledge, it is difficult to separate knowledge from its original network and, therefore, transplant it into another. Knowledge is embedded across different layers of nested networks, each of which has a different degree of separability and transplantability, defined as the extent to which a set of knowledge can be

separated from the layer of nested networks it is embedded in, and fully performs its original function in the corresponding layer of networks in other countries, respectively. Knowledge is embedded in physical, human, and social capital (Malmberg *et al.*, 1996). Unlike the knowledge embedded in physical capital such as materials, products, and machinery, the knowledge embedded in human capital, an important part of which is embedded in the network of relationships, cannot be appropriately "taken out of context without losing much of its value" (Malmberg *et al.*, 1996: 92). Therefore, interpersonal networks comprise one of the important determinants of knowledge flow (Singh, 2005; Zander and Kogut, 1995). Further, the knowledge embedded in social capital (Burt, 1992; Coleman, 1988; Inkpen and Tsang, 2005) is much harder to transfer across countries because it is historically bound and involves mobilization of actors and routines in local networks (Porter and Sölvell, 1998; Sölvell and Zander, 1998). In addition, as institutional characteristics within a local innovation system are specialized to facilitate the knowledge flow within the system (Sölvell and Zander, 1998), diffusion of knowledge embedded in social capital across country borders would require hard endeavors (Kogut, 1991).

In short, due largely to the embeddedness of knowledge in multiple layers of nested networks in a country, it is difficult for an outsider to figure out the overall system in which particular knowledge to be imitated is embedded. This, in turn, may result in a higher degree of information asymmetry and causal ambiguity. Likewise, it is difficult for a would-be imitator to extract a certain part of knowledge that is embedded in a system of nested networks and transplant it into another system of nested networks. This, in turn, may result in a higher degree of non-transplantability or factor immobility and, thus, uniqueness.

Geographic Scope as an Independent Source of Isolating Mechanisms

The embeddedness of knowledge in networks of a country enables us to understand that geographic scope can constitute an independent source of isolating mechanisms. More specifically, the embeddedness of knowledge in networks of a country can engender causal ambiguity and uniqueness, independent from intrinsic characteristics of knowledge. First, the main source of causal ambiguity from geographic scope is information asymmetry (Arrow, 1974) from the liabilities of outsidership (Johanson and Vahlne, 2009), while that from intrinsic characteristics of knowledge is tacitness or complexity (Reed and Defillippi, 1990). These two sources of causal ambiguity are independent because knowledge that is neither tacit nor complex can be causally ambiguous (Ambrosini and Bowman, 2010; Fabrizio and Thomas, 2012; King and Zeithaml, 2001; Zander and Kogut, 1995), if the would-be imitators suffer from the liability of outsidership and thus information asymmetry because it is the insidership to the network through which firms can learn new knowledge, build trust, develop commitment, and identify opportunities (Johanson and Vahlne, 2009).

Likewise, the main source of uniqueness from geographic scope is inseparability and non-transplantability of knowledge, while that from intrinsic characteristics of knowledge is difference or originality. These two sources of uniqueness are also independent from each other because knowledge that is not unique to the firms in a country can be unique to firms from other countries because the knowledge embedded in the multiple layers of nested networks of the country can be inseparable and thus non-transplantable or immobile. More specifically, unlike the firms in a country that share the multiple layers of nested networks into which the knowledge to be imitated is embedded, firms from other countries do not share the multiple layers of the networks and, therefore, may find it difficult to transplant the knowledge into networks of their home countries because the knowledge is unique or specific to the networks of the country.

Figure 3.2 illustrates different sources of causal ambiguity and uniqueness in each of the intrinsic characteristics of knowledge and geographic scope.

The next section develops hypotheses on the main and interaction effects of the two independent sources of causal ambiguity and uniqueness, in the order of the intrinsic characteristics of knowledge, geographic scope, and their interaction. In each sub-section, I first derives hypotheses on causal ambiguity and then on uniqueness.

HYPOTHESES

Intrinsic Characteristics of Knowledge and Isolating Mechanisms

Extant research studies expound that intrinsic characteristics of knowledge can increase causal ambiguity and uniqueness, thus creating isolating mechanisms (Hoetker and Agarwal, 2007; Reed and Defillippi, 1990; Rumelt, 1984). This section first derives hypotheses on causal ambiguity arising from intrinsic characteristics of knowledge, and then derives hypotheses on uniqueness arising from intrinsic characteristics of knowledge.

Causal Ambiguity from Intrinsic Characteristics of Knowledge

The intensity of causal ambiguity from the intrinsic characteristics of knowledge can be determined by the degree of tacitness (Reed and Defillippi, 1990) and complexity/ decomposability (Reed and Defillippi, 1990; Rivkin, 2000; Simon, 1962) of the knowledge.

Tacitness: Tacitness refers to hard-to-articulate and non-codified knowledge that has been accumulated via learning-by-doing (Reed and Defillippi, 1990). Tacit knowledge could be harder to imitate (Zander and Kogut, 1995) because tacitness could impede the flow of knowledge (Teece, 1981a). In general, newer knowledge is more tacit (Nelson and Winter, 1982) and, thus, less codifiable (Nonaka, 1991, 1994) and difficult to understand (Sørensen and Stuart, 2000). In

this light, a patent drawn on recent knowledge would be tacit and thus hard to imitate. Therefore, if a patent has less citations to prior art per claim (Hoetker and Agarwal, 2007), then we can expect that the knowledge in the patent is more recent and tacit, and thus that the patent would be harder to imitate.

Hypothesis 3.1a: The less citations to prior art per claim of a patent, the longer it takes for other firms to cite that patent.

***Complexity*:** Complexity refers to the extent to which information is required to understand the interaction among independent components (Winter, 1987; Zander and Kogut, 1995). Complex knowledge could be harder to imitate. If the knowledge is created integrating efforts of multiple inventors, it would be complex because it results from interactions between the inventors who might have different types of prior knowledge (Shane, 2000): knowledge becomes more complex when "it draws upon distinct and multiple kinds of competencies" (Zander and Kogut, 1995: 79). Therefore, it would be much harder to fully understand the overall structure of the complex system and, thus, take much more time to fully process the information possessed by the inventors and their interactions as the number of inventors increase.

Hypothesis 3.1b: The greater the number of inventors a patent has, the longer it takes for other firms to cite that patent.

Uniqueness from Intrinsic Characteristics of Knowledge

***Specificity*:** Knowledge would be difficult to flow if it is from or related with assets that are specific or unique to the target firm. The sources of these unique assets include asset-specificity (dedicated asset) (Williamson, 1985), co-specialized assets (Teece, 1986), obtaining knowledge not intended for the imitator (Knott, 2003), and language and symbols (Arrow, 1974; March and Simon, 1958; Nonaka, 1991, 1994). As such, if the knowledge to be imitated has been developed for specific purposes as opposed to general ones, it is less likely that the knowledge is applicable

to other firms. In this light, we can expect that it will take longer for other firms to cite a patent, if it more specific.

Hypothesis 3.2a: The more specific a patent is, the longer it takes for other firms to cite that patent.

***Originality*:** When knowledge is original, it could be harder to imitate. Knowledge drawn from broad technological roots is original because it synthesizes divergent ideas (Jaffe and Trajtenberg, 2002). As original knowledge is based on the combination of previous knowledge residing in multiple fields, it is unique in terms of content. This would in turn require exponentially increasing capability to fully process all the information in the knowledge and eventually make it mobile. Therefore, we can expect that it will take longer for other firms to cite a patent, if it more original.

Hypothesis 3.2b: The more original a patent is, the longer it takes for other firms to cite that patent.

Geographic Scope and Isolating Mechanisms

As discussed, geographic scope can be an independent dimension of causal ambiguity and uniqueness: liability of outsidership can lead to causal ambiguity and inseparability/non-transplantability of knowledge can engender uniqueness. This section first derives hypotheses on causal ambiguity from geographic scope and then on uniqueness from geographic scope.

Causal Ambiguity from Geographic Scope

Information asymmetry generated by the liability of outsidership from the relevant networks (Johanson and Vahlne, 2009) is the main source of causal ambiguity from geographic scope. As knowledge is embedded in the multiple layers of nested networks in a country, outsiders from these networks would suffer from a higher degree of information asymmetry (Arrow, 1974) and

higher search costs (Rumelt, 1984) to identify which part of the imitated firm's knowledge is associated with competitiveness (i.e., unknown unknowns) (Lippman and Rumelt, 1982). This, in turn, would increase causal ambiguity or bounded rationality (Lippman and Rumelt, 1982; Mahoney and Pandian, 1992), creating isolating mechanisms.

Knowledge acquired from closed countries could be harder to imitate. Would-be imitators could suffer from a higher degree of liability of outsidership when countries from which a focal firm acquired its knowledge are not open to other countries because the countries would have fewer networks connected outside their borders and thus it is less likely that the would-be imitators could access the relevant networks. Therefore, if the focal firm acquires knowledge from countries that are more closed to the rest of the world, the would-be imitators could suffer from a higher degree information asymmetry (Arrow, 1974), which would increase the degree of causal ambiguity and thus create isolating mechanisms. This discussion leads to the following hypothesis.

Hypothesis 3.3: The more closed the countries in a patent's backward citations, the longer it takes for other firms to cite that patent.

Uniqueness from Geographic Scope

Inseparability and, thus, non-transferability of knowledge from one set of multiple layers of nested networks to another are the main source of uniqueness from geographic scope. As knowledge is embedded in the multiple layers of nested networks in a country, knowledge is unique not only in its own intrinsic characteristics but also its relationship with the network it is embedded in (or 'relationship-specific knowledge' (Johanson and Vahlne, 2009)). As such, it is difficult to separate particular knowledge from the multiple layers of the nested networks and completely transplant it into the contexts of other countries (Malmberg *et al.*, 1996). Consequently, the knowledge would become sticky (Kogut, 1991; Teece, 1977) and less mobile

across country borders. This, in turn, would increase the degree of uniqueness or asset-specificity (Lippman and Rumelt, 1982; Mahoney and Pandian, 1992), creating isolating mechanisms.

Knowledge acquired from multiple countries could be harder to imitate. As knowledge is specific to the network it is embedded in and each country constitutes a minimal set of networks for an independent system of innovation to fully operate, knowledge acquired from multiple countries is specific to multiple sets of independent networks, thus becoming more unique. In this situation, as networks are conduits for knowledge flow (Podolny and Page, 1998), would-be imitators would suffer from a higher degree of factor immobility because it is less likely that would-be imitators share the complete networks and therefore it is much harder to transplant the knowledge embedded in multiple sets of independent networks into a new context. This would, in turn, increase the time to imitation.

Hypothesis 3.4: The greater the number of countries in a patent's backward citations, the longer it takes for other firms to cite that patent.

Interactions between Intrinsic Characteristics of Knowledge and Geographic Scope

The two independent sources of causal ambiguity and uniqueness can jointly further increase isolating mechanisms. In other words, in addition to the independent influences, the interaction between intrinsic characteristics of knowledge and geographic scope can further increase causal ambiguity and uniqueness, thus facilitating the creation of isolating mechanisms. This section first derives hypotheses on the influences of the interaction on increasing causal ambiguity and then on uniqueness.

Interaction for Causal Ambiguity

A higher degree of information asymmetry from geographic scope could increase the influences on causal ambiguity of intrinsic characteristics of knowledge by increasing the degree

of tacitness or complexity of the knowledge to be imitated. When knowledge to be imitated is tacit or complex, it may require more 'social capital' (Inkpen and Tsang, 2005; Sölvell and Zander, 1998) or 'relationship-specific knowledge' (Johanson and Vahlne, 2009) in the multiple layers of networks in which the knowledge is embedded to fully understand the causal relationship. In other words, the social capital in the network could increase the fluidity of knowledge and it is "particularly valuable when knowledge is difficult or costly to codify" (Porter and Sölvell, 1998: 444). If the information asymmetry from the liability of outsidership prevents the imitating firms from utilizing these clues to figure out the causal relationship, then the imitating firms may find the knowledge even more tacit or complex because they cannot benefit from the clues residing in multiple layers of nested networks or social capital: most valuable information usually resides in the enduring relationships or social capital, not in price signals (Powell, 1990). Therefore, what is explicit to those who have access to the entire network can be tacit or complex to others who do not have, or have only partial access to the network.

In this light, knowledge acquired from closed countries can increase the influences on causal ambiguity of the intrinsic nature of knowledge because it is more likely that the information asymmetry from the liability of outsidership would impede an imitating firm from utilizing the additional clues necessary to fully understand the underlying mechanisms of the knowledge to be imitated. As a consequence, knowledge that is neither tacit nor complex to the insiders can be tacit and complex if the would-be imitators suffer from information asymmetry engendered by the liability of outsidership. Or the imitating firms from other countries may find tacit or complex knowledge even more tacit or complex than the firms in the country because the imitating firms lack clues that reside in multiple layers of network. Therefore, we can expect that causal ambiguity from intrinsic characteristics of knowledge would be *more* stringent when a focal firm acquires its knowledge from more closed/distant countries.

Hypothesis 3.5: The effects of the intrinsic characteristics of knowledge on causal ambiguity would be positively moderated by broader geographic scope between countries in a patent's backward citations.

Interaction for Uniqueness

A higher degree of inseparability and non-transplantability from geographic scope could increase the influences on uniqueness of intrinsic characteristics of knowledge by increasing the degree of specificity or originality of the knowledge to be imitated. As discussed, knowledge can be unique due to not only its own intrinsic characteristics but also its relationship with the network it is embedded in (or 'relationship-specific knowledge' (Johanson and Vahlne, 2009)). As such, it is difficult to separate particular knowledge from the network it is embedded in and transplant it into the networks of other countries. If the imitating firms' networks do not share many layers of the nested networks in which the knowledge to be imitated in embedded, the imitating firms then may find specific or original knowledge even more specific or original, because, within a country, "institutions, norms and values become increasingly specialized and unique, adding to the fluidity of knowledge exchange in the local environment and preventing diffusion to the outside" (Sölvell and Zander, 1998: 409). As such, factors that are mobile for the firms within a country could be immobile for the firms in other countries due to the lack of common layers of networks. Therefore, what is not specific or original to the firms that share the same layers of networks can be different or original to the firms that do not share the networks because the knowledge is specific to those networks.

In this light, knowledge acquired from multiple countries can increase the influences on uniqueness of the intrinsic nature of knowledge because it is less likely that the imitating firm shares the layers of networks in which the knowledge to be imitated is embedded. As such, knowledge that is neither specific nor original to the firms that share the layers of nested network

can be specific or original if the would-be imitators face non-transplantability because they do not share many of the layers of networks in which knowledge is embedded. Therefore, we can expect that uniqueness from the intrinsic characteristics of knowledge would be *more* stringent when a focal firm acquires its knowledge from multiple/isolated countries.

Hypothesis 3.6: The effects of the intrinsic characteristics of knowledge on uniqueness would be positively moderated by broader geographic scope between countries in a patent's backward citations.

Figure 3.3 illustrates the relationships between constructs and expected sign of each hypothesis.

DATA AND METHODOLOGY

Data

Empirical studies have expounded that the patent citations can be a good proxy for measuring knowledge flow. Patent citations show the trails of new knowledge creation (Singh, 2005) because "a citation of Patent X by Patent Y means that X represents a piece of previously existing knowledge upon which Y builds" (Jaffe *et al.*, 1993: 580). This holds true even after controlling for the spurious citations (Jaffe *et al.*, 1998).

In this light, this research study takes the patent level for the level of analysis and employs the '*OECD, Citations database, June 2010*' database for the empirical analyses. The OECD citations database provides patent information filed to the European Patent Office (EPO) or via the Patent Co-operation Treaty (PCT) from 1978 onward. For the information of inventors and applicants, the information in the '*OECD, REGPAT database, June 2010*' is joined with the OECD citations database. The trade data are retrieved from *World Development Indicators (WDI) Online* database of the World Bank and *UNCTADstat* database of UNCTAD, respectively.

This research study focuses its empirical contexts on the semiconductor industry. This research setting is relevant for two reasons. First, the semiconductor industry is a representative high-tech industry with rapid technological progress and a well-established global standard and presence (Almeida, 1996; Breznitz, 2007; Henisz and Macher, 2004; Ziedonis, 2004). Second it controls for possible influences from industry structure (Ahuja *et al.*, 2008). Patent information in the semiconductor industry was retrieved from the OECD citations database using the International Patent Classification (IPC) subclass of "H01L: Semiconductor devices; Electric solid state devices not otherwise provided for". The sample consists of 24,018 patents that are filed during the period of 1978 ~ 2009 and have at least one forward citation.

Variables

Dependent variable

The dependent variable for the degree of isolation is the time, in months, to the first forward citation by other firms, which measures the length of time between the patent application and the first forward citation to the patent. The rationale behind this measure is that it takes longer to cite a patent that is isolated. In other words, an isolating mechanism can manifest itself in the decreased likelihood of imitation and/or the delay in time to imitation (Zander and Kogut, 1995).

Independent variables

This research study employs four sets of independent variables: *causal ambiguity* and *uniqueness* for *intrinsic characteristics* and *geographic scope*. First, for causal ambiguity from the intrinsic characteristics of knowledge, two variables are employed: *Tacitness* and *Complexity*. Tacitness is operationalized as '1- maturity of technology'. The maturity of technology is measured as the number of citations to prior art per claim of a new patent (i.e., the number of

backward citations in a new patent) divided by the maximum number of the number of citations to prior art per claim of a new patent in the sample (Hoetker and Agarwal, 2007). Complexity of a new patent is measured as the number of inventors in a focal patent divided by the maximum number of the number of inventors in the sample.

Second, for uniqueness from the intrinsic characteristics of knowledge, this research study employs two variables: S*pecificity* and *Originality*. Specificity captures the extent to which a new patent is applicable to multiple technological fields and is operationalized as '1 - generality'. The generality is measured as the total number of IPC classifications of a new patent divided by the maximum number of the total number of IPC classifications of a new patent in the sample. The originality of a patent captures the extent to which a focal patent draws upon a wide range of technological fields and can be measured for a patent *i* as follows (Jaffe and Trajtenberg, 2002):

$$Originality_i = 1 - \sum_{k=1}^{N_i} \left(\frac{NCITED_{ik}}{NCITED_i}\right)^2$$

where *k* represents the index of patent class, N_i the number of different classes to which the cited patents belong, and *NCITED* the number of patents cited by the focal patent.

Third, for causal ambiguity from geographic scope, this research study employs *Closedness*. For Closedness, we first calculate a negative value of the natural logarithm of trade volume of a country in a given year. The trade volume is measured as the sum of both export and import (= (export + import)).[6] For a patent, we select the minimum trade value among the inventor

[6] As the focus of this research study is on the flow of information into and out of a country in an *absolute* rather than *relative* perspective, Closedness used in this research study is not weighted by the economic size of countries. Closedness is derived from the measure for trade openness, which captures the proportion of trade to the overall size of a country's economic activities (i.e., trade openness = (export + import) / (GDP × 2)). However, Closedness employed in this paper is not weighted by the economic size of countries (i.e., GDP), because doing so would make the measure positively biased toward large economies. For instance, United States and Japan would rank high in terms of the closedness, when weighted with the economic size of countries. The high closedness in these countries is not because these countries are closed in terms of trade flow but because they have relatively large economic sizes.

countries as the trade volume for the patent. Closedness is then operationalized as '- ln(Trade) - min(-ln(Trade))'

Fourth, for uniqueness from geographic scope, this research study employs Number of Countries. Number of Countries is measured as the number of countries found in the backward citations of a new patent.

Control variables

In order to control for the quality of a patent that can have a significant influence on the likelihood and the speed for a patent to be cited, this research study includes a dummy variable to classify each patent's membership in the '*OECD, Triadic Patent Families database, June 2010'*. The OECD Triadic Patent Families database provides at least three advantages. First, by systematically integrating patents filed in the three largest database (i.e., USPTO, EPO, and JPO), this database allows us to analyze the patenting activities and citations trends more comprehensively in global scale (Martínez, 2010), thus providing an ideal information source for testing the role of geographic scope in creating isolating mechanisms. Second, this database enables us to mitigate the 'home advantage' effect, a home-country bias toward the propensity of patent filing. As patents are in most cases first filed in the home country of inventors, national patent offices have disproportionally large number of patents filed by domestic applicants. This effect can distort the degree of domestic innovation in a particular country and raises issues when patents data are used for international comparison (Criscuolo, 2006; Martínez, 2010). The 'OECD Triadic Patent Families' mitigates the 'home advantage' effect by considering only those patents that have been filed to three patent offices and, therefore, provides an ideal setting for international comparison of knowledge acquisition and its implications for isolating mechanisms. Third, this database allows us to control for the quality of patents. As filing patents in the

multiple patent offices incurs non-trivial costs, firms have incentive to protect only those patents worth the costs (Martínez, 2010). Indeed, previous studies have found that the membership in the patent families is associated with higher patent quality (Harhoff, Scherer, and Vopel, 2003; Lanjouw and Mody, 1996; Sapsalis, Van Pottelsberghe De La Potterie, and Navon, 2006). Therefore, we can expect that patents with membership in the patent families are higher in quality and, by this way, we can control for the quality of patents that could influence the time to forward citations by other firms. Table 3.1 lists descriptive statistics of and correlations between variables.

Methodology

In order to estimate the effects of covariates on the time to the first citation, this research study employs an accelerated failure-time (AFT) model (Cox and Oakes, 1984; Kalbfleisch and Prentice, 1980) with the following specification:

$$\ln(\boldsymbol{T}) = \boldsymbol{X\beta} + \sigma\boldsymbol{\varepsilon}$$

where $\ln(\boldsymbol{T})$ is a natural logarithm of the time to the first forward citation, $\boldsymbol{X}$ is a covariate matrix, $\boldsymbol{\beta}$ is a coefficient vector, σ is the scale parameter, and $\boldsymbol{\varepsilon}$ is a vector of error terms that follow Weibull distribution. In order to control for unobservable firm level heterogeneity, this research study also incorporates the shared frailty model (Gutierrez, 2002; Hougaard, 1984), which is a survival model analog of random effect model, by specifying patent applicant *i* to share the same frailty. A positive coefficient indicates longer time to the first forward citation and thus a higher degree of isolation.

RESULTS

Table 2 lists the results of AFT regressions with a Gamma shared frailty specification. Models 1~3 show the regressions for the main effects of both intrinsic characteristics of knowledge and geographic scope on degree of isolation (i.e., Hypotheses 3.1~3.4). A contrast between Mode1~2 and Model 3 reveals that the coefficients of Tacitness (Model 1) and No of Countries (Model 2) that are statistically insignificant turn to be significant in Model 3. This finding is consistent with the complementary relationship between intrinsic characteristics of knowledge and geographic scope hypothesized in Hypotheses 3.5~3.6, which is discussed in more depth below. Model 3 is the full model for testing Hypotheses 3.1~3.4. First, all of the coefficients of intrinsic characteristics of knowledge and geographic scope except Closedness (H3.3) are statistically significant at $p < 0.05$ level. Second, however, the coefficients for Complexity (H3.1b) have a negative sign, which is the opposite of the expected direction. Therefore, Hypotheses 3.1a (Tacitness), 3.2a (Specificity), 3.2b (Originality), and 3.4 (No of Countries) are supported. A one unit increase in Tacitness, Specificity, Originality, or No of Countries would increase the time to the first forward citation by a factor of 2.139524 (=exp(0.7605834)), 1.466731 (=exp(0.3830358)), 1.048657 (=exp(0.0475102)), 1.016471 (=exp(0.0163365)), respectively, while a one unit increase in Complexity increases the time to the first forward citation by a factor of 0.761539 (=exp(-0.272414)), thus *decreasing* the time to the first forward citation. These results show that each of intrinsic characteristics of knowledge and geographic scope is an *independent* source of isolating mechanisms.

Models 4~9 list the regressions to test hypotheses for the interaction effects (i.e., Hypotheses 3.5~3.6). All four variables for the intrinsic characteristics of knowledge are interacted with each of the two geographic scope variables: *Closedness* and *No of Countries*. First, Models 4~6 list the interactions with Closedness. As shown in Models 5 and 6, among the

interaction terms, only the coefficient for Specificity is statistically significant at $p < 0.05$ level. Therefore, Hypothesis 3.6 (interaction between uniqueness and geographic scope) is supported with Specificity and Closedness. Second, Models 7~9 show the regression results for the interaction effects with No of Countries. In Model 7, none of the coefficients for causal ambiguity are statistically significant. In Model 8, all the coefficients of interactions between uniqueness and geographic scope are statistically significant and have the expected positive sign. Therefore, Hypothesis 3.6 (interaction between uniqueness and geographic scope) is supported with Specificity/Originality and No of Countries. The results of the interaction effects are graphically illustrated and discussed in more depth in the discussion section.

In sum, the empirical analyses show that (1) for the main effect hypotheses, Tacitness (H3.1a), Specificity (H3.2a), and Originality (H3.2b) for the intrinsic characteristics of knowledge are supported and No of Countries (H3.4) for the geographic scope is also supported, while Complexity (H3.1b) and Closedness (H3.3) are not supported; and (2) the interaction effect hypothesis for uniqueness and geographic scope (H3.6) is supported with both Closedness and No of Countries, while the interaction effect hypothesis for causal ambiguity and geographic scope (H3.5) is not supported.

Figure 3.4 illustrates changing marginal effects of specificity and originality on the time to the first citation across different values of Closedness and No of Countries. The isolating acceleration factor refers to a factor by which the time to forward citation increases as specificity and originality increase by one unit. As three graphs in Figure 3.4 illustrate, the effects of specificity and originality on time to forward citation increase as Closedness and No of Countries increase. For instance, as shown in Figure 3.4(a), a unit increase in specificity would increase time to forward citation by a factor of 2 when Closedness is around 2. A unit increase in

specificity, however, would increase the time to forward citation by a factor of 4 when Closedness is around 4.

Figures 3.5 and 3.6 depicts the changing impacts on delay in time to first forward citation of Specificity and Originality across various levels of Closedness and No of Countries in 2- and 3-dimensional graphs, respectively. Overall, the graphs show that increases in Specificity and Originality would have much stronger impacts on delaying the time to first forward citation at a higher level of Closedness and No of Countries. These results highlight the importance and the complementarity aspect of geographic scope in creating isolating mechanisms: geographic scope can increase overall causal ambiguity and uniqueness of knowledge to be imitated, *jointly with* intrinsic characteristics of knowledge.

The negative and significant coefficient of Complexity (H3.1b) could result from possible network effects associated with the inventors (Singh, 2005). More specifically, instead of increasing causal ambiguity through exponentially increasing interactions, a large number of inventors in a patent could provide increased access to the knowledge in the patent, shortening the time to the first forward citation (Almeida and Kogut, 1999). In other words, as the inventors could function as a living template of knowledge in the patent (Hoetker and Agarwal, 2007), a larger number of inventors could increase the probability of the focal patent being cited by other firms by providing increased access to the template.

In the control variables, the coefficients of Quality consistently show statistically significant negative signs across the 9 models. This result implies that imitators target patents with higher quality more than those with lower quality and, thus, that a patent with higher quality is vulnerable to faster imitation.

I conduct multiple checks for robustness of the empirical findings. First, the results are robust across different specifications for the distribution. I specify exponential, log-logistic, and

log-normal distribution for the AFT models. Overall, the results are consistent with the Weibull specification. Second, the results are robust across sub-samples. I divide the sample spanning over a 32-year period (i.e., 1978~2009) into two sub-samples, each of which spans a 16-year period before and after 1994, respectively. The regressions within these subsamples yield consistent results with those from the entire sample.

DISCUSSION AND CONCLUSION

This research study examines the role of geographic scope in creating isolating mechanisms and maintains that, *independently from* and *jointly with* intrinsic characteristics of knowledge, geographic scope can increase overall causal ambiguity and uniqueness of knowledge to be imitated, thus creating isolating mechanisms. Empirical tests with patent citations data in the semiconductor industry filed to the European Patent Office (EPO) during the period of 1978~2009 corroborate the main thesis of this chapter.

Overall, the empirical findings corroborate the main thesis of this chapter that, *independently from* and *jointly with* intrinsic characteristics of knowledge, geographic scope can increase overall causal ambiguity and uniqueness of knowledge to be imitated, thus creating isolating mechanisms. The extended time to the first forward citation of the patents that have characteristics of tacitness, specificity, and originality demonstrates that intrinsic characteristics of knowledge can create isolating mechanisms. Likewise, the extended time to the first forward citation of the patents that are acquired from broad geographic scope, even after controlling for the effects from intrinsic characteristics of knowledge, confirms that geographic scope can be an *independent* source of isolating mechanisms. Furthermore, the positive interaction effects between intrinsic characteristics of knowledge and geographic scope supports that geographic scope can increase isolating mechanisms *jointly with* intrinsic characteristics of knowledge.

This research study contributes to the literature of international business and strategic management in at least three ways. First, it suggests a broader range of factors to be considered as sources of isolating mechanisms. In addition to the intrinsic characteristics of knowledge such as tacitness, complexity, specificity, and originality, this research study shows that geographic scope of knowledge acquisition can be an *independent* source of isolating mechanisms and can also work *jointly* with the intrinsic characteristics of knowledge when creating isolating mechanisms.

Second, it complements work on the role of geographic scope of knowledge acquisition in creating competitive advantage by showing that geographic scope can also help sustain that advantage. Most of the extant studies have largely focused on the role of geographic scope of knowledge acquisition in *creating* competitive advantage (Lahiri, 2010; Porter, 1998; Singh, 2008). Complementing the extant literature, this research study suggests that geographic scope of knowledge acquisition can also help firms *sustain* their competitive advantage by creating isolating mechanisms thus making it difficult for their competitors to imitate the knowledge they create through innovation. This point further highlights that firms can sustain their competitive advantage by strategically leveraging their geographic resources even when their intrinsic characteristics of knowledge are not conducive to creating isolating mechanisms.

Third, it introduces a new motivation of firm internationalization, the creation of isolating mechanisms. Extending the second contribution into the context of international business, this research study suggests that firms can be motivated to internationalize their knowledge acquiring activities for the purpose of creating isolating mechanisms to sustain their competitive advantage. Extant literature on the motivation of firm internationalization has largely focused on the creation of competitive advantage by either exploiting firm-specific advantages (Dunning, 1988; Hymer, 1960/1976) or exploring new strategic resources in international markets (Makino *et al.*, 2002;

Moon and Roehl, 2001). Complementing the extant literature, this research study suggests that internationalization of knowledge acquisition can be a strategic option to *sustain* competitive advantage by leveraging the attributes of international markets that help firms create isolation mechanisms. In other words, the liability of foreignness (Hymer, 1960/1976; Teece, 1981b; Zaheer, 1995) or the liability of outsidership from relevant networks (Johanson and Vahlne, 2009) and the country heterogeneity (Ricart *et al.*, 2004), when strategically utilized, can be sources of *sustainable* strategic rents (Foss and Foss, 2005; Peteraf, 1993). In this light, firms can be motivated to acquire knowledge from international market even when the knowledge is available in domestic markets and, therefore, there is no need for them to seek the knowledge in international markets. In sum, firms can be motivated to internationalize their knowledge acquiring activities not only to *create* competitive advantage via exploitation/exploration but also to *sustain* the competitive advantage via isolating mechanisms.

Like any studies, this research study has limitations, which provides avenues for future studies. First, this research study operationalizes one aspect of isolating mechanisms as the time to first forward citation. This variable is based on the insights of Zander and Kogut's studies on time to imitation (e.g., Zander and Kogut, 1995). Although the patent citations can effectively capture knowledge flow (Jaffe *et al.*, 1998; Jaffe *et al.*, 1993; Singh, 2005), they are not free from drawbacks (Song and Shin, 2008). Future studies employing other techniques to measure isolating mechanisms such as the patent citation network analysis (trajectory), main path/island (Chang, Wu, and Leu, 2010; Mina, Ramlogan, Tampubolon, and Metcalfe, 2007), and the dynamic time warping (DTW) would complement the current research study.

Second, empirical analyses consistently show the opposite results to the prediction for the hypotheses regarding complexity. As discussed, this result might be due to the possible confounding effects of the number of inventors. In other words, the number of inventors, instead

of operationalizing intrinsic complexity of knowledge, can capture the inter-inventor network, which can facilitate knowledge flow across geographic locations (Almeida and Kogut, 1999). Future studies employing other variables to operationalize different aspects of complexity that is free from the network effects (e.g., decomposability (Rivkin, 2000)) would provide important implications by contrasting the results with those with the number of inventors.

Third, this study employed data only from the semiconductor industry in order to control for possible industry effects (Ahuja *et al.*, 2008). As such, this industry context is a boundary condition of the theoretical framework advanced in this research study (Bacharach, 1989). Future studies in the context of other industries than the semiconductor industry could help generalizing the findings and expand the boundary condition. In addition, future studies on discrepancies of the role of isolating mechanism across industries or on the role of isolating mechanism in inter-industry imitations could provide important implications.

Lastly, future studies on the dynamic aspects of networks can also provide important implications. More specifically, the density of various types of network all over the world has increased with the acceleration of globalization. One the one hand, given the network as conduits for knowledge flow, this could provide an increased access to the knowledge dispersed over the world. On the other hand, this could make more causally ambiguous and unique the knowledge acquired from multiple countries due to increasing interactions among the multiple layers of networks. As such, it would provide of critical implications to systematically examine whether changes in the network density would reinforce or blur the role of geographic scope of knowledge acquisition in creating isolating mechanisms.

FIGURES AND TABLES

Table 3.1: Descriptive Statistics and Correlations

	Variables	Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	Time to Forward Citation	43.31	37.51	1	346	1							
(2)	Tacitness	0.97	0.02	0	1	0.04	1						
(3)	Complexity	0.15	0.1	0.06	1	-0.07	-0.07	1					
(4)	Specificity	0.91	0.05	0	0.98	0.03	0.05	-0.05	1				
(5)	Originality	0.5	0.29	0	0.94	-0.03	-0.2	0.12	-0.14	1			
(6)	Closedness	1.5	0.6	0	6.19	0.1	0.09	-0.08	0.05	-0.11	1		
(7)	No of Countries	2.32	0.96	1	7	0	-0.54	0.01	-0.03	0.16	0	1	
(8)	TPF	0.79	0.41	0	1	-0.02	-0.03	0.06	-0.14	0.03	-0.05	-0.01	1

Table 3.2: Results of AFT Regressions (Weibull) with Gamma Shared Frailty (DV: time to first forward citation)

Variables	Hypotheses & Expected Signs	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Intrinsic Characteristics										
Tacitness	**H3.1a (+)**	.272		.761**	.662	.78**	.826	.997	.731*	.845
		(0.256)		(0.010)	(0.285)	(0.008)	(0.192)	(0.123)	(0.013)	(0.200)
Complexity	**H3.1b (+)**	-.281***		-.272***	-.141	-.274***	-.171	-.398**	-.275***	-.393**
		(0.000)		(0.000)	(0.349)	(0.000)	(0.256)	(0.004)	(0.000)	(0.004)
Specificity	**H3.2a (+)**	.395***		.383***	.385***	-.244	-.23	.384***	-.193	-.206
		(0.000)		(0.000)	(0.000)	(0.398)	(0.428)	(0.000)	(0.480)	(0.453)
Originality	**H3.2b (+)**	.0503**		.0475*	.048*	.0775	.0767	.048*	-.0316	-.0258
		(0.007)		(0.012)	(0.011)	(0.129)	(0.140)	(0.011)	(0.479)	(0.577)
Geographic Scope										
Closedness	**H3.3 (+)**		.00693	.0062	-.0543	-.375*	-.326	.00603	.00609	.00599
			(0.551)	(0.594)	(0.890)	(0.027)	(0.454)	(0.604)	(0.601)	(0.606)
No of Countries	**H3.4 (+)**		.00845	.0163*	.0166*	.0167**	.0167**	.0803	-.226*	-.204
			(0.107)	(0.011)	(0.010)	(0.009)	(0.010)	(0.670)	(0.022)	(0.336)
Interaction with Closedness										
Tacitness × Closedness	**H3.5 (+)**				.0759		-.0327			
					(0.852)		(0.937)			
Complexity × Closedness	**H3.5 (+)**				-.092		-.072			
					(0.347)		(0.464)			
Specificity × Closedness	**H3.6 (+)**					.429*	.42*			
						(0.018)	(0.021)			
Originality × Closedness	**H3.6 (+)**					-.0194	-.0187			
						(0.529)	(0.552)			
Interaction with No of Countries										
Tacitness × No of Countries	**H3.5 (+)**							-.0744		-.0342
								(0.702)		(0.864)
Complexity × No of Countries	**H3.5 (+)**							.0532		.05
								(0.321)		(0.354)
Specificity × No of Countries	**H3.6 (+)**								.246*	.251*
									(0.020)	(0.018)
Originality × No of Countries	**H3.6 (+)**								.0358†	.0332†
									(0.051)	(0.080)
Controls										
Quality (Membership in Triadic		-.0847***	-.0935***	-.0843***	-.084***	-.0829***	-.0827***	-.084***	-.084***	-.0838***
Patent Family)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Dummies		Included	Included	Included	Included	Included	Included	Included	Included	Included
Constant		3.45***	4.01***	2.94***	3.01**	3.51***	3.44***	2.73**	3.51***	3.42***
		(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.001)	(0.006)	(0.000)	(0.001)
Observations		22482	22445	22444	22444	22444	22444	22444	22444	22444
Chi-squared		1293.178	1163.859	1212.469	1213.414	1218.978	1219.516	1213.661	1220.521	1221.424
Log-likelihood		-28252.179	-28230.049	-28204.179	-28203.706	-28200.924	-28200.656	-28203.583	-28200.153	-28199.701

p-values in parentheses; ; † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3.1: Dimensions of Causal Ambiguity and Uniqueness: Intrinsic Characteristics of Knowledge and Geographic Scope

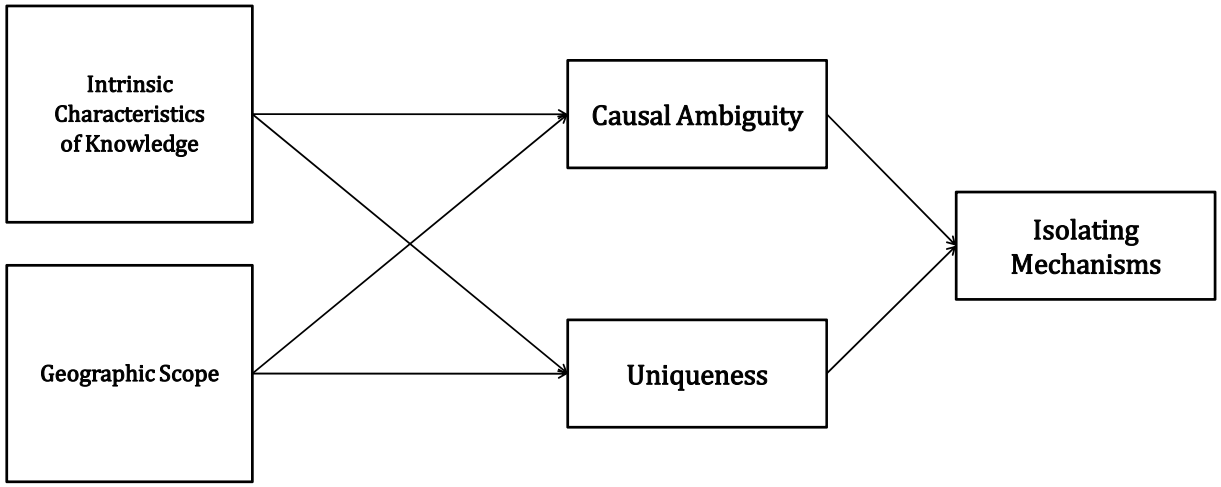


Figure 3.2: Sources of Causal Ambiguity and Uniqueness

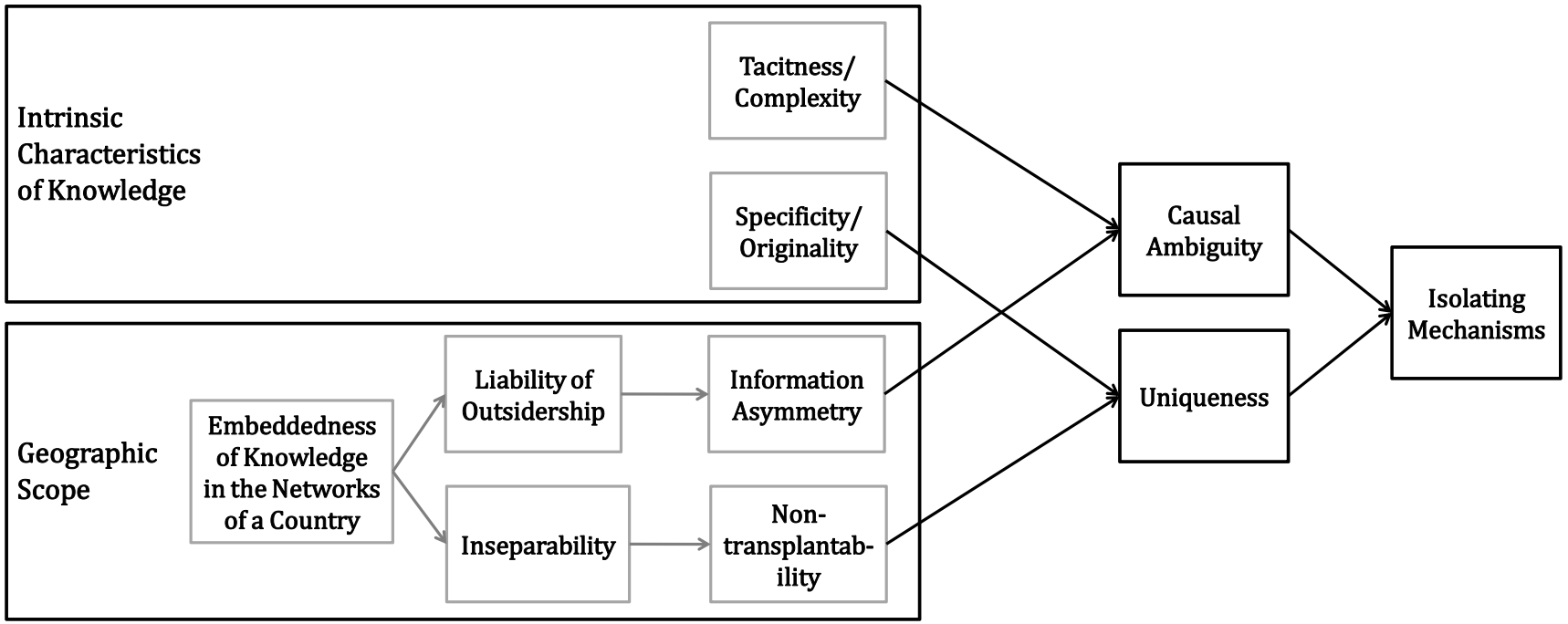


Figure 3.3: Relationships between Constructs and Expected Sign of Each Hypothesis

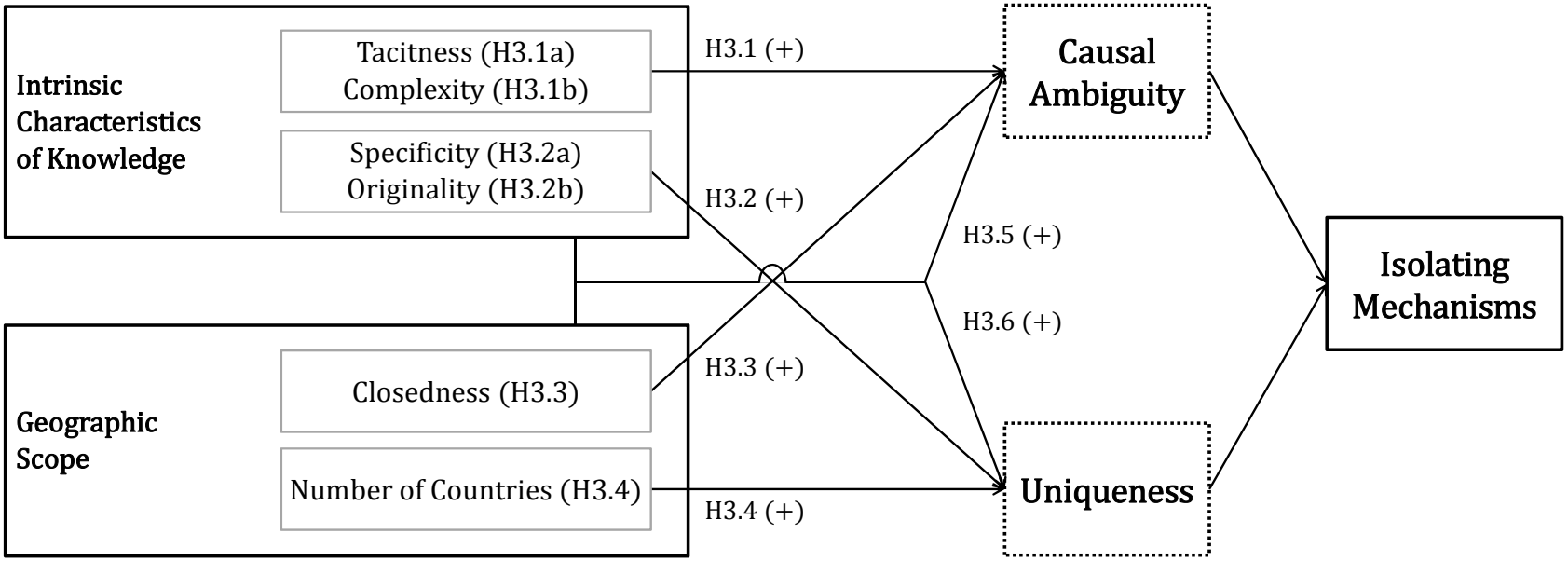
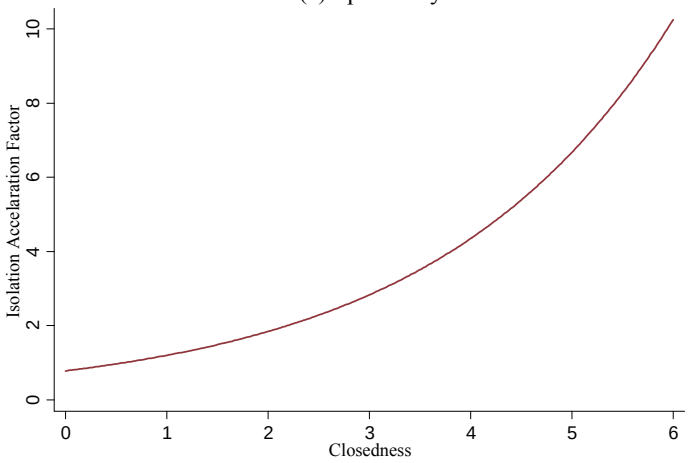
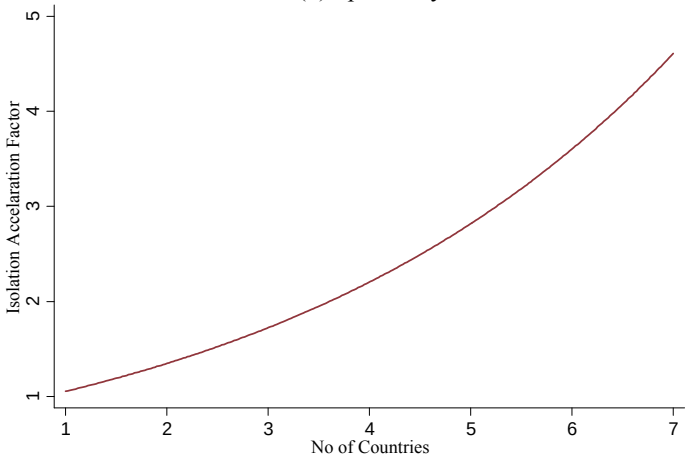


Figure 3.4: Isolating Acceleration Factors of Specificity and Originality across No of Countries and Closedness

(a) Specificity



(b) Specificity



(c) Originality

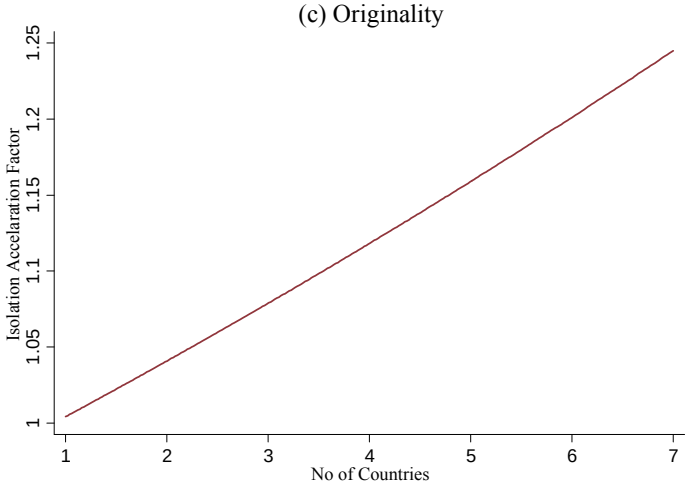
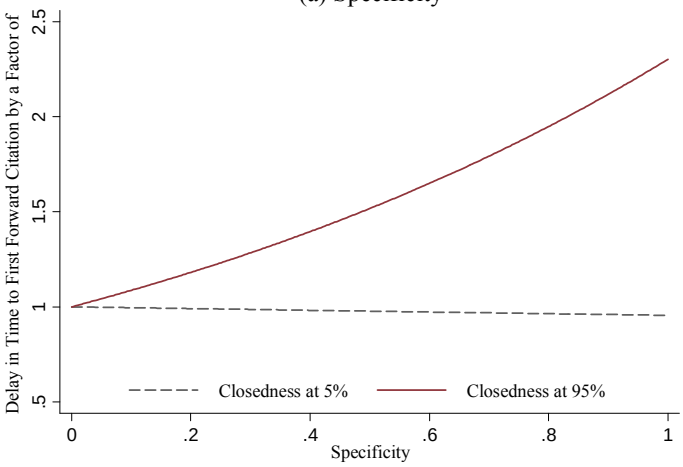
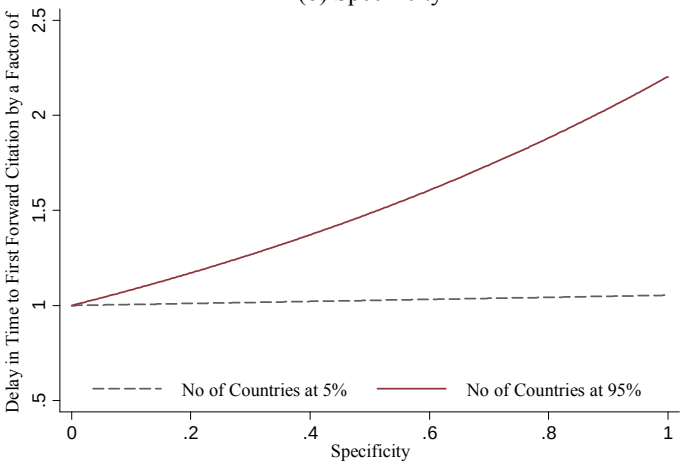


Figure 3.5: Changing Impacts on Delay in Time to First Forward Citation of Specificity and Originality across Various Levels of Closedness and No of Countries (2D)

(a) Specificity



(b) Specificity



(c) Originality

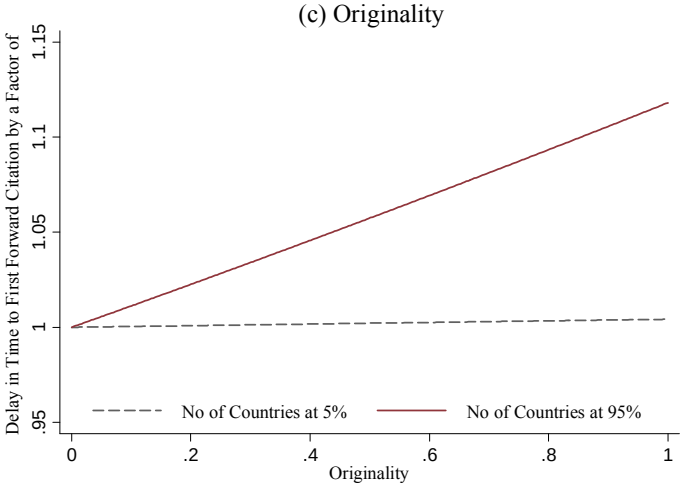
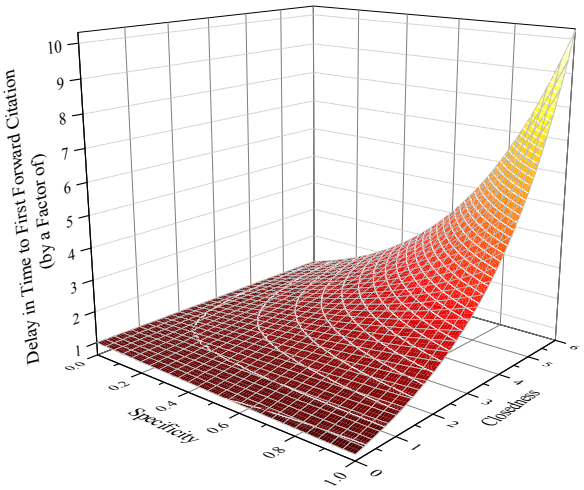
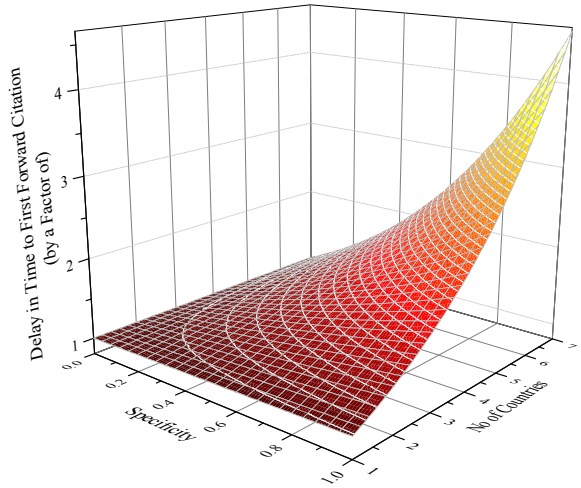


Figure 3.6: Changing Impacts on Delay in Time to First Forward Citation of Specificity and Originality across Various Levels of Closedness and No of Countries (3D)

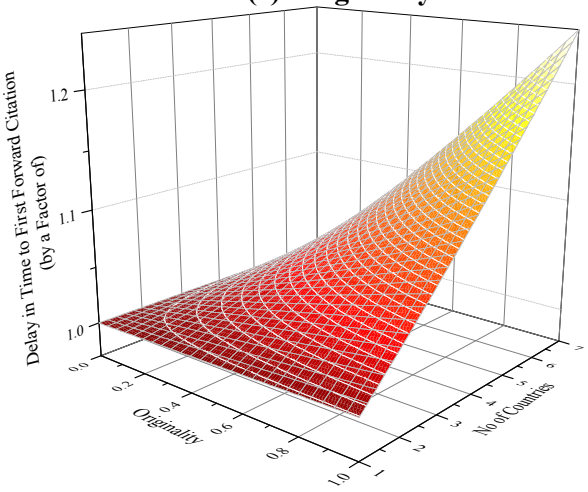
(a) Specificity



(b) Specificity



(c) Originality



CHAPTER 4: EQUIFINALITY AND FUNCTIONAL EQUIVALENCE IN ISOLATING MECHANISMS

INTRODUCTION

Chapter 3 advances a thesis that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms and empirically examines that geographic scope of knowledge acquisition can create isolating mechanisms, *independently from* and *jointly with* the intrinsic characteristics of knowledge. Considering the fact that intrinsic characteristics of knowledge and geographic scope of knowledge acquisition constitute two independent sources of isolating mechanisms but work together when creating isolating mechanisms, we are interested in following questions on the general relationship among the causal factors from the sources of isolating mechanisms. For instance, *do they work in a combination or independently? Is it a single path or multiple paths leading to isolating mechanisms? Are the causal factors from the two sources mutually substitutable*? Given the importance of isolating mechanisms in sustaining competitive advantage, answers to these questions would have important theoretic and managerial implications, especially when developing strategy to sustain competitive advantage utilizing a set of unique bundles of resources and capabilities a firm has.

In order to address these questions, this chapter examines the *relationship* among causal factors leading to isolating mechanisms. This chapter first discusses a theoretical framework that geographic scope of knowledge acquisition or the extent to which a firm acquires its knowledge from multiple countries can be an independent source of causal factors creating isolating mechanisms. It then maintain that the causal factors creating isolating mechanisms can be equifinal and functionally equivalent in nature (Gresov and Drazin, 1997; Merton, 1967). I employ the fuzzy set qualitative comparative analysis (QCA) (Fiss, 2007; Ragin, 2000, 2008;

Schneider *et al.*, 2010) to test the theoretical framework. Unlike standard analytic techniques that are based on the assumptions of *unifinal*, *additive*, and *symmetric* causal relationships, QCA assumes *equifinal*, *conjunctural*, and *asymmetric* causal relationships (Wagemann and Schneider, 2010). In this light, the fuzzy-set QCA would be ideal for studying configurations or interdependence of factors leading to isolating mechanisms (Greckhamer *et al.*, 2008) and, thus, provides an ideal analytical tool to address the questions posed in this chapter.

Empirical analyses with patent data in the semiconductor industry corroborate the main thesis of the study that causal factors linked to the creation of isolating mechanisms can be equifinal and functionally equivalent in nature. There can be many paths leading to isolating mechanisms and different sources of causal factors can be mutually substitutable. More specifically, firms can create isolating mechanisms utilizing the intrinsic characteristics of knowledge or leveraging geographic scope of knowledge acquisition.

This research study contributes to the literature in at least two ways. First, it provides a better understanding of the nature of causal factors leading to isolating mechanisms. Employing the fuzzy set QCA method, I demonstrate that equifinality and functional equivalence is at the center of the phenomenon, in which the causal factors work as a combination rather than as a single factor. These findings regarding the equifinal, functionally equivalent, and configurational nature of the causal factors leading to isolating mechanisms enable us to have a better understanding of the extant literature and the phenomenon, by complementing the findings of extant studies that are based on the assumption of unifinal and additive nature of the causal factors. Furthermore, these findings can help managers devise and implement more viable strategies for developing isolating mechanisms: in order to achieve the same goal of creating isolating mechanisms, managers can develop strategies that utilize unique combinations of resources and capabilities available within their firms.

Second, this research study suggests a new motivation of firm internationalization. Literature on motivation of firm internationalization has largely focused on exploitation and/or exploration of firm-specific advantage utilizing location-specific advantage for the purpose of *generating* competitive advantage (Dunning, 1977; 1988; Rugman and Verbeke, 1992). In addition to these motivations, this research study suggests that firms may internationalize their knowledge acquisition activities for the purpose of *sustaining* competitive advantage by utilizing an independent source of isolating mechanisms (i.e., geographic scope of knowledge acquisition).

The following sections first briefly review literature on isolating mechanisms and then develop hypotheses on the nature of causal conditions leading to isolating mechanisms. Then the hypotheses are tested employing the fuzzy set QCA method. Implications of the empirical findings are discussed.

THEORY AND HYPOTHESES

Sources of Causal Factors Creating Isolating Mechanisms

Extant literature has largely focused on the intrinsic characteristics of knowledge as a source of isolating mechanisms (Lippman and Rumelt, 1982; Mahoney and Pandian, 1992; Rumelt, 1984). It is of critical importance, however, to recognize that *geographic scope of knowledge acquisition* can also be an independent source of causal ambiguity and uniqueness, the two features leading to isolating mechanisms. More specifically, due to embeddedness of knowledge in the multiple layers of networks within a country, those who do not have membership in relevant networks can face causal ambiguity and uniqueness, even in the absence of causal ambiguity or uniqueness from intrinsic characteristics of knowledge. Therefore, as illustrated in Figure 3.1, *independently from* intrinsic characteristics of knowledge, geographic scope of knowledge acquisition can increase overall causal ambiguity and uniqueness of knowledge to be

imitated, thus creating isolating mechanisms. This implies that each of the intrinsic characteristics of knowledge and geographic scope of knowledge acquisition can be an independent source of causal ambiguity and uniqueness. The following subsections first discuss causal ambiguity and uniqueness from intrinsic characteristics of knowledge and geographic scope, and then advance a theoretical framework that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms.

Causal Ambiguity and Uniqueness from Intrinsic Characteristics of Knowledge

Causal ambiguity from the intrinsic characteristics of knowledge can be determined by the degree of tacitness (Reed and Defillippi, 1990) and complexity/decomposability (Reed and Defillippi, 1990; Rivkin, 2000; Simon, 1962) of the knowledge. Tacitness refers to hard-to-articulate and non-codified knowledge that has been accumulated via learning-by-doing (Reed and Defillippi, 1990). Tacit knowledge could be harder to imitate (Zander and Kogut, 1995) because tacitness may impede the flow of knowledge (Teece, 1981a). Complexity refers to the extent to which information is required to understand the interaction among independent components (Winter, 1987; Zander and Kogut, 1995). Complex knowledge could be harder to imitate because it requires more endeavors to fully understand the overall structure of the complex system and, thus, requires exponentially increasing capability and necessitates much more time to fully process the information necessary to imitate the knowledge.

Uniqueness due to the intrinsic characteristics of knowledge can be created by specificity and originality. Knowledge will have difficulty flowing if it is from or related with assets that are specific to a source or transaction. The sources of the specificity include asset-specificity (dedicated asset) (Williamson, 1985), co-specialized assets (Teece, 1986), obtaining knowledge not intended for the imitator (Knott, 2003), and language and symbols (Arrow, 1974; March and

Simon, 1958; Nonaka, 1991, 1994). Likewise, original knowledge could be harder to imitate. Knowledge drawn from broad technological roots is original because it synthesizes divergent ideas (Jaffe and Trajtenberg, 2002). As original knowledge is based on the combination of previous knowledge residing in multiple fields, it is unique in terms of content and specific in terms of purpose. This would in turn make it hard to transfer the knowledge to the places not intended for its purpose.

Causal Ambiguity and Uniqueness from Geographic Scope of Knowledge Acquisition

As established in the literature of national systems of innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993), knowledge is embedded in multiple layers of networks within each country (Granovetter, 1985; Powell *et al.*, 1996), leading to each country possessing a distinct set of knowledge (Malmberg *et al.*, 1996; Sölvell and Zander, 1998). The multiple layers of networks include the networks of physical, human, and social capital (Malmberg *et al.*, 1996). These multiple layers of networks imply that, in addition to the intrinsic characteristics, knowledge can be 'relationship-specific' (Johanson and Vahlne, 2009) and/or reside in 'social capital'[7] (Inkpen and Tsang, 2005; Sölvell and Zander, 1998). These multiple layers of networks could increase the fluidity of knowledge (Sölvell and Zander, 1998) to its members and thus make it easier to flow knowledge to insiders (Johanson and Vahlne, 2009). Indeed, countries themselves are isolated from each other (Sölvell and Zander, 1998).

Due largely to the embeddedness of knowledge in the networks of a country, outsiders to the relevant networks would suffer from the liability of outsidership (Johanson and Vahlne, 2009) or the liability of unconnectedness (Baum and Oliver, 1992) and thus would find it harder to

[7] This research study adopts Inkpen and Tsang's definition of social capital: "..... the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization - a definition that accommodates both the private and public good perspectives of social capital" (Inkpen and Tsang, 2005: 151).

figure out the overall system in which particular knowledge to be imitated is embedded. This, in turn, could result in a higher degree of information asymmetry and could increase causal ambiguity. Even when the knowledge is not causally ambiguous, it could be difficult for a would-be imitator to extract or separate a certain part of knowledge that is embedded in a system of nested networks and transplant it into another system of nested networks because the knowledge embedded in the network of *relationships* cannot be appropriately "taken out of context without losing much of its value" (Malmberg *et al.*, 1996: 92). In addition, the inseparability and non-transplantability are expected to persist because, within a country, "institutions, norms and values become increasingly specialized and unique, adding to the fluidity of knowledge exchange in the local environment and preventing diffusion to the outside" (Sölvell and Zander, 1998: 409). This kind of factor immobility could in turn increase uniqueness.

Geographic Scope as an Independent Source of Isolating Mechanisms

The foregoing discussion demonstrates that geographic scope can engender causal ambiguity and uniqueness, *independent from* intrinsic characteristics of knowledge. First, the main source of causal ambiguity from geographic scope is *information asymmetry* (Arrow, 1974) due to the liabilities of outsidership (Johanson and Vahlne, 2009), while the main source of causal ambiguity arising from intrinsic characteristics of knowledge is tacitness and/or complexity (Reed and Defillippi, 1990). These two sources of causal ambiguity are independent because knowledge that is neither tacit nor complex can be causally ambiguous (Ambrosini and Bowman, 2010; King and Zeithaml, 2001; Zander and Kogut, 1995), if the would-be imitators suffer from the liability of outsidership and thus information asymmetry because it is the insidership to the network through which firms can learn new knowledge, build trust, develop commitment, and identify opportunities (Johanson and Vahlne, 2009).

Likewise, the main source of uniqueness from geographic scope is *inseparability* and *non-transplantability* of knowledge, while that from intrinsic characteristics of knowledge is specificity and/or originality. These two sources of uniqueness are also independent from each other because knowledge that is not unique to the firms in a country can be unique to firms from other countries because the knowledge embedded in the multiple layers of nested networks of the country can be inseparable and thus non-transplantable or immobile. More specifically, unlike the firms in a country that share the multiple layers of nested networks into which the knowledge to be imitated is embedded, firms from other countries do not share the multiple layers of the networks and, therefore, may find it hard to transplant the knowledge into networks of their home countries because the knowledge is unique or specific to the networks of the host country.

Equifinal and Functionally Equivalent Nature of Causal Factors Creating Isolating Mechanisms

The brief review of isolating mechanisms in the preceding sections provides two important implications in terms of the nature of causal conditions leading to isolating mechanisms: *equifinality* and *functional equivalence.* First, there can be many causal paths leading to creation of isolating mechanisms. In evolutionary biology, as summarized in Table 2.1, isolating mechanisms are understood as "arranged like a series of hurdles; if one breaks down, another must be overcome" (Mayr, 1970: 66). In this light, the inter-specie gene flow is impeded by multiple series of isolating mechanisms, usually in several pairs. In management literature, Lippman and Rumelt (1982: 420) maintain that "..... Factors of production cannot become mobile unless they are known ..... factors of production that are immobile not only because they are unique, but also because their replication is a difficult and uncertain endeavor". In fact, it is the interaction between these two characteristics of isolating mechanisms that increases the

height of the barriers to imitation. Unlike the implicit assumption in the literature, tacit knowledge may not be a necessary condition for an isolating mechanism (Knott, 2003: 942; Mahoney, 2005: 207). These statements suggest that it is a configuration of causal factors rather than a single factor that creates isolating mechanisms. More fundamentally, these statements imply that there exist multiple paths or combinations of causal factors leading to creation of isolating mechanisms, each of which would be sufficient but not necessary to create isolating mechanisms (i.e., equifinality). As the two sources of causal ambiguity and uniqueness, *intrinsic characteristics of knowledge* and *geographic scope of knowledge acquisition*, are independent from each other, we can expect that different combinations of causal factors from each of the two sources of causal ambiguity and uniqueness can lead to creation of isolating mechanisms. This discussion leads to the following hypothesis on equifinality.

Hypothesis 4.1: **[Equifinality]** Different combinations of causal factors from each of the two sources of causal ambiguity and uniqueness can lead to creation of isolating mechanisms.

Second, different sources of causal ambiguity and uniqueness can be functionally equivalent (Gresov and Drazin, 1997; Merton, 1967). In Chapter 3, I demonstrate that geographic scope of knowledge acquisition can increase causal ambiguity and uniqueness *independently from* and *jointly with* intrinsic characteristics of knowledge, thus creating isolating mechanisms. Given the equifinality of causal factors linked to the creation of isolating mechanisms, causal factors from the two different sources that increase causal ambiguity and uniqueness, respectively, can play similar roles in creating isolating mechanisms. In this light, causal ambiguity and uniqueness from geographic scope can be functionally equivalent to (or substitute) those from intrinsic characteristics of knowledge because geographic scope can constitute an independent source of

causal ambiguity and uniqueness. This discussion leads to the following hypothesis on functional equivalence.

Hypothesis 4.2: **[Functional Equivalence]** Causal ambiguity and uniqueness originated from geographic scope can be functionally equivalent to (or substitute) those from intrinsic characteristics of knowledge when creating isolating mechanisms.

EMPIRICAL ANALYSES

Methodology

This research study takes a set-theoretic approach (Fiss, 2007) and employs 'Fuzzy-Set/Qualitative Comparative Analysis 2.5.' program (Ragin, Drass, and Dave, 2006). First introduced by Ragin (2000) as an extension of the crisp-set QCA (Ragin, 1987), the fuzzy-set QCA takes a set-theoretic approach and analyzes how the membership in causal conditions leads to an outcome of interest. For this purpose, the fuzzy-set QCA first calibrates the degree of membership of data along the three anchor points (i.e., full non-membership, the cross over point, and full membership) so as to allow the membership scores to range from 0.0 to 1.0 (Ragin, 2000, 2008). The fuzzy-set QCA then analyzes how the configurations of the membership in causal conditions are linked to membership in the outcome variable. The fuzzy-set QCA is appropriate to address the research questions posed in this chapter because "These [set-theoretic] methods are premised on the idea that different conditions *combine* rather than compete with each other in creating an outcome and that there may be different combinations of conditions that lead to the same outcome, thus making them well suited for studying configurations and equifinality" (Fiss, 2007: 1183). In other words, the conjunctural focus of the fuzzy-set QCA enables us to address the questions on configurations or interdependence of factors. As equifinality and functional

equivalence among the causal factors linked to creation of isolating mechanisms assume multiple paths or configurations of factors and their interdependence when creating isolating mechanisms, the fuzzy-set QCA is an ideal analytical technique to address the research questions. In fact, these questions are difficult to address with the standard regressions analysis because of its unifinal and additive perspective (Fiss, 2007; Wagemann and Schneider, 2010).

Sample and Calibration

Sample

For empirical tests of the hypotheses, this research study employs the '*OECD, Citations database, June 2010*' database and analyzes 951 patents in the semiconductor industry applied for in the year 2000. The OECD citations database provides patent information filed to the European Patent Office (EPO) or via the Patent Co-operation Treaty (PCT) from 1978 onward. Therefore, this sample allows us to capture recent patent activities and, at the same time, to have enough time for a first forward citation (up to 115 months). For the information of inventors and applicants, the information in the '*OECD, REGPAT database, June 2010*' is joined with the OECD citations database. The trade data are retrieved from *World Development Indicators (WDI) Online* database of the World Bank.

Outcome Measures

The dependent variable for the degree of isolation is the time to the first forward citation by other firms, which measures the length of time between the patent application and the first forward citation to the patent in months. The rationale behind this measure is that it takes longer to cite a patent that is isolated. When a firm creates isolating mechanisms, other firms find it difficult to imitate its knowledge. Although knowledge tends to leak despite the effort to prevent it (Almeida and Kogut, 1999; Jaffe *et al.*, 1993), the rate of leakage would be slower when the

knowledge is hard to imitate because the imitation requires much more efforts than otherwise. Therefore, an isolating mechanism can manifest itself in the decreased likelihood of imitation and/or the delay in time to imitation (Zander and Kogut, 1995). In other words, if knowledge is hard to imitate due to isolating mechanisms, it would be less likely for other firms to imitate the knowledge (Hoetker and Agarwal, 2007). Moreover, even though imitated, it will take longer. As such, if a patent contains hard-to-imitate knowledge, then it could take longer for other firms to cite the patent.

The dependent variable is calibrated using the direct method described in Ragin (2008), using the three anchor points for calibration (i.e., full non-membership, the cross over point, and full membership). Patents with the first forward citation longer than 90 months were coded as fully in the set of isolating mechanisms, while those with less than 6 months as fully out of the set. The cross over point was set as 33 months. These anchor points are selected following Ragin's (2008) recommendation that external criteria be used to calibrate measures: each of the three anchor points corresponds to 95^{th}, 50^{th}, and 5^{th} percentile of patents in the semiconductor industry filed to EPO during the period of 1978 ~ 2009.

Causal Attributes

This research study employs four sets of causal variables of isolating mechanisms: *causal ambiguity* and *uniqueness* for each of *intrinsic characteristics* and *geographic scope*. First, for causal ambiguity from the intrinsic characteristics of knowledge, two variables are employed: *Tacitness* and *Complexity*. Tacitness is operationalized as '- maturity of technology'. The maturity of technology is measured as the number of citations to prior art per claim of a new patent (i.e., the number of backward citations in a new patent) (Hoetker and Agarwal, 2007). Each of 0,-4,-13 is coded as full membership, the cross over point, and full non-membership in to

the set of Tacitness, respectively. These three anchor points correspond to 99th, 50th, and 1st percentile of patents in the semiconductor industry filed to EPO during the period of 1978 ~ 2009. Complexity of a new patent is measured as the number of inventors in a focal patent. Each of 6, 3, and 1 is coded as full membership, the cross over point, and full non-membership into the set of Complexity, respectively. These three anchor points correspond to 95th, 50th, and 1st percentile of patents in the semiconductor industry filed to EPO during the period of 1978 ~ 2009.

Second, for uniqueness from the intrinsic characteristics of knowledge, this research study employs two variables: S*pecificity* and *Originality*. Specificity captures the extent to which a new patent is applicable to a specific technological field and is measured as '- the total number of International Patent Classification (IPC) classes of a new patent'. This is on the basis of the assumption that a patent can be applicable to multiple technological fields if is classified into multiple IPC codes. Each of -1,-5, and -15 is coded as full membership, the cross over point, and full non-membership into the set of Specificity, respectively. These three anchor points correspond to 99th, 50th, and 1st percentile of patents in the semiconductor industry filed to EPO during the period of 1978 ~ 2009. The originality of a patent captures the extent to which a focal patent draws upon a wide range of technological fields and can be measured for a patent *i* as follows (Jaffe and Trajtenberg, 2002):

$$Originality_i = 1 - \sum_{k=1}^{N_i} \left(\frac{NCITED_{ik}}{NCITED_i}\right)^2$$

where *k* represents the index of patent class, N_i the number of different classes to which the cited patents belong, and *NCITED* the number of patents cited by the focal patent. As Originality is a ratio variable, I coded 1, 0.5, and 0 as full membership, the cross over point, and full non-membership into the set of Originality, respectively.

Third, for causal ambiguity from geographic scope, this research study employs *Closedness*. Closedness is operationalized as '-Openness'. Openness is measured an annual trade volume of a country: the sum of both export and import (i.e., Trade = (export + import)). This measure is based on the assumption that the less the flow of information across countries, the higher the causal ambiguity to outsiders. In this sense, trade volume is used to operationalize the flow of information across country borders. For a patent, I select the minimum trade volume among the inventor countries as the trade volume for the patent. Each of -1.32e+11, -7.61e+11, and -2.85e+12 is coded as full membership, the cross over point, and full non-membership into the set of Closedness, respectively. These three anchor points correspond to 99th, 50th, and 1st percentile of patents in the semiconductor industry filed to EPO during the period of 1978 ~ 2009.

Fourth, for uniqueness from geographic scope, this research study employs Number of Countries. Number of Countries is measured as the number of countries found in the backward citations of a new patent. Table 4.1 shows descriptive statistic and correlations of the variables. Each of 5, 2, and 1 is coded as full membership, the cross over point, and full non-membership into the set of No. of Countries, respectively. These three anchor points correspond to 99th, 50th, and 1st percentile of patents in the semiconductor industry filed to EPO during the period of 1978 ~ 2009.

RESULTS

Hypothesis 4.1: Configurations of Causal Conditions

Analyzing the sufficiency of combinations of causal conditions can be an effective way of dealing with causal complexity (Ragin, 2000). For this, the truth table algorithm (Ragin, 2008) is employed to test Hypothesis 4.1. Table 4.2 shows the truth tables used in the analysis.

When using the truth table algorithm, two decisions should be made on the threshold for frequency distribution and consistency. For the frequency distribution (or strength-of-evidence) threshold, in compliance with the recommendation, the minimum number of cases to be considered for the analysis was set at 4, which covers 82% of the cases.[8] For the consistency threshold, the minimum level of consistency level for solution was set at 0.8.[9]

Applying the set-reduction algorithm, the truth table can be reduced into *intermediate* and *parsimonious* solutions with different application of counterfactual analyses in the presence of the limited diversity.[10] The intermediate solution that uses only the easy counterfactuals yields the following six solutions:[11]

SPECIFICITY • ~ORIGINALITY • TACITNESS +
~SPECIFICITY • COMPLEXITY • TACITNESS +
NOOFCOUNTRIES • ~SPECIFICITY • ~ORIGINALITY +
NOOFCOUNTRIES • ~ORIGINALITY • COMPLEXITY +
CLOSEDNESS • NOOFCOUNTRIES • ~ORIGINALITY +
CLOSEDNESS • NOOFCOUNTRIES • ~SPECIFICITY • COMPLEXITY
→ ISOLATING MECHANISMS

where '~' denotes the logical negation, '•' the logical operator 'and', '+' the logical operator 'or', and '→' the logical implication operator.

The parsimonious solution that utilizes any counterfactual cases yields the following six relatively simple combinations linked to the creation of isolating mechanisms:

[8] Ragin and Davey (2008: 78) recommend that "the configurations selected should capture ***at least*** 75-80% of the cases."

[9] The minimum recommended threshold for the consistency level is 0.75 (Ragin, 2008: 136).

[10] For further discussion on counterfactual analyses and limited diversity, refer to Part IV of Ragin (2008).

[11] In line with the theoretical argument developed in this research study, when producing the intermediate solution, it is assumed that presence of each of the six causal factors (i.e., tacitness, complexity, specificity, originality, closedness, and no of countries) is linked to the creation of isolating mechanisms.

TACITNESS • ~ORIGINALITY +
TACITNESS • COMPLEXITY • ~SPECIFICITY +
~ORIGINALITY • ~SPECIFICITY +
COMPLEXITY • ~ORIGINALITY +
~ORIGINALITY • CLOSEDNESS +
~SPECIFICITY • CLOSEDNESS
→ ISOLATING MECHANISMS

Table 4.3 integrates the intermediate and parsimonious solutions and graphically illustrates configurations of factors leading to the creation of isolating mechanisms, adopting notations in recent studies (Fiss, 2011; Ragin and Fiss, 2008).[12] First, full circles represent the presence of a condition while crossed-out circles represent the absence of a condition. Second, large circles represent core conditions, while some small circles indicate peripheral conditions. The core element refers to "those causal conditions under which the evidence indicates a strong causal relationship with the outcome of interest" and the peripheral[13] element denotes "those for which the evidence for a causal relationship with the outcome is weaker" (Fiss, 2011: 394). Third, blank space represents a ""don't care" situation in which the causal condition may be either present or absent" (Fiss, 2011: 407). The overall solution has consistency[14] of 0.70 and coverage[15] of 0.63.

Solution 1 indicates that the absence of Specificity and Originality as core conditions as well as the presence of the number of countries as a peripheral condition is sufficient for creation of isolating mechanisms. In fact, however, this configuration implies that it might take long time

[12] Ragin maintains that "In general, intermediate solutions are preferred because they are of the most interpretable" (2008: 175). Following his recommendation, Table 3 is structured utilizing results in the intermediate solution. In other words, all the causal factors in Table 3 appear in the intermediate solution and those specified as 'core' also appear in the parsimonious solution.

[13] The peripheral element is also called as 'complementary' or 'contributing' conditions (Ragin and Fiss, 2008: 204).

[14] Consistency $(X_i \leq Y_i) = \sum[\min(X_i, Y_i)] / \sum(X_i)$, where Y_i denotes i^{th} outcome and X_i to i^{th} causal condition (Ragin, 2006: 297).

[15] Coverage $(X_i \leq Y_i) = \sum[\min(X_i, Y_i)] / \sum(Y_i)$, where Y_i denotes i^{th} outcome and X_i to i^{th} causal condition (Ragin, 2006: 301).

for the patents to be cited by other firms not because of the barriers to imitation but rather because of the low quality of the patents (i.e., the absence of Specificity and Originality as core conditions).

Solutions 2a and 2b illustrate combinations of causal factors when the absence of Specificity is a core condition. First, Solution 2a indicates that the presence of Tacitness and Complexity as core conditions in the absence of Specificity would be sufficient to create isolating mechanisms. In contrast, Solution 2b illustrates that the presence of Closedness as a core condition and that of Complexity and No of Countries as peripheral conditions can also be linked to the creation of isolating mechanisms when Specificity is absent. This substitution of causal ambiguity from intrinsic characteristics of knowledge with causal ambiguity and uniqueness from geographic scope implies the existence of functional equivalence derived in Hypothesis 4.2, whose results will be discussed in more detail later in this chapter.

Solutions 3a ~ 3c also demonstrate similar results with those in Solution 2a and 2b when Originality is absent as a core condition. More specifically, like those in Solution 2a and 2b, each of 3a and 3b highlights the role of causal ambiguity from intrinsic characteristics of knowledge, while Solution 3c expounds a path leading to the creation of isolating mechanisms utilizing causal ambiguity from geographic scope.

In sum, these results show that each causal factor (i.e., Tacitness, Complexity, Specificity, Originality, Closedness, and No of Countries) constitutes an INUS condition, which stands for "an *insufficient* but *necessary* part of a condition which is itself *unnecessary* but *sufficient* for the results" (Mackie, 1965: 245; Ragin and Sonnett, 2008; Wagemann and Schneider, 2010) and implies "a nonredundant part of one sufficient condition" linked to an outcome (Mackie, 1965: 252). In other words, each of the six *solutions* constitutes a 'minimal sufficient condition' (Mackie, 1965) for the creation of isolating mechanisms, or a path leading to isolating

mechanisms, in which each of the six *causal factors* constitutes a *necessary* condition. This point highlights the equifinal and conjuncture nature of causal factors leading to isolating mechanisms, thus supporting the existence of functional equivalence among the causal factors. These results corroborate Hypothesis 4.1 that "Each of causal ambiguity and uniqueness constitutes a sufficient condition for isolating mechanisms".

Hypothesis 4.2: Functional Equivalence

The functional equivalence refers to substitutable conditions (Ragin, 2006), which can be tested by examining whether a set of conditions joined by a logical 'or' constitutes a necessary condition for the outcome (Schneider *et al.*, 2010). As shown in Table 4.4, all of the substitutable necessary conditions for the intrinsic characteristics of knowledge and geographic scope constitute necessary conditions with consistency[16] higher than 0.75. In addition, these substitutable necessary conditions are non-trivial in that their coverage[17] rates are around 0.60. Therefore, Hypothesis 4.2 "Causal ambiguity and uniqueness originated from geographic scope can be functionally equivalent to (or substitute) those from intrinsic characteristics of knowledge when creating isolating mechanisms" is supported.

In sum, the empirical results to test Hypotheses 4.1 and 4.2 corroborate the main thesis of the study that the causal factors leading to isolating mechanisms can be equifinal and functionally equivalent in nature: it is different types of configuration or combinations of causal factors that creates isolating mechanisms and, in these configurations, causal factors from different sources can be functionally equivalent, thus being mutually substitutable.

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[16] Consistency $(Y_i \leq X_i) = \sum[\min(X_i, Y_i)] / \sum(Y_i)$, where Y_i denotes i^{th} outcome and X_i to i^{th} causal condition (Ragin, 2006: 297).

[17] Coverage $(Y_i \leq X_i) = \sum[\min(X_i, Y_i)] / \sum(X_i)$, where Y_i denotes i^{th} outcome and X_i to i^{th} causal condition (Ragin, 2006: 303).

DISCUSSION

In addition to the unifinal and additive approach assumed in the standard analytic techniques, the equifinal and conjunctural approach taken in this research study provide unique and important theoretical and managerial implications complementary to the insights in the extant literature. First, from the theoretical perspective, the results provide better understanding of extant literature on isolating mechanisms. As discussed, extant literature on isolating mechanisms explains existence of isolating mechanisms as a result of 'a series of hurdles' (Mayr, 1970: 66), 'the rich connection between uniqueness and causal ambiguity' (Lippman and Rumelt, 1982), or 'existence of asset-specificity and bounded rationality' (Mahoney and Pandian, 1992). The set-theoretic approach taken in this research study with the fuzzy set QCA method helps us more clearly understand that these explanations in the extant literature on isolating mechanisms imply an equifinal and conjunctural nature of causal factors leading to isolating mechanisms.

Second, the findings of this research study also have implications for the motivation of firm internationalization. This research study takes a broad definition of firm internationalization as a process of acquiring knowledge from international markets via various governance structures, which encompasses all forms of the governance structures that are employed to acquire knowledge from international markets (including, but not limited to, merger and acquisition, strategic alliances, joint venture). In addition to the established knowledge in the extant international business literature that focuses mostly on the exploitation, exploration, or 'seeking' aspects of the motivations of multinational corporations' (MNCs) investments, this research study suggests that firm internationalization to acquire knowledge from international markets can be a strategic option to *sustain* competitive advantage by leveraging the attributes of international markets that help an effective creation of isolating mechanisms. From this

perspective, the theoretical argument and empirical findings of this research study suggests a new motivation of firm internationalization as a strategy to create isolating mechanisms, thus achieving and maintaining *sustainable* competitive advantage. Extant literature on the motivations of firm internationalization emphasizes exploitation of firm-specific advantages (Dunning, 1988; Hymer, 1960/1976) and, recently, exploration or augmentation of strategic assets (Makino *et al.*, 2002; Moon and Roehl, 2001). In other words, the extant literature on the motivation of firm internationalization focuses on the exploitation of firm resources and capabilities (or ownership advantage) to explore or to seek resources and capabilities unavailable or preempted by competitors in domestic markets (e.g., natural-resource seeking, market seeking, efficiency-seeking, and strategic asset-seeking (Dunning, 1995; 2000)). While the extant international business literature focuses on *creating* competitive advantage via exploitation/exploration, this research study suggests a new motivation of firm internationalization by illuminating the role of geographic scope in *sustaining* the competitive advantage (Barney, 1991). In other words, the liability of foreignness (Hymer, 1960/1976; Teece, 1981b; Zaheer, 1995) or the liability of outsidership from relevant networks (Johanson and Vahlne, 2009) and the country heterogeneity (Ricart *et al.*, 2004), when strategically utilized, can be sources of *sustainable* strategic rents (Foss and Foss, 2005; Peteraf, 1993). Therefore, firms can implement internationalization not only to *create* competitive advantage via exploitation/exploration but also to *sustain* the competitive advantage via isolating mechanisms from geographic scope.

The results also provide managers with a better understanding of different types of viable strategies to create isolating mechanisms. The most practical question would be *what* to do and *how* to create isolating mechanisms: *which recipe would be the best to achieve the goal of creating isolating mechanisms?* In other words, in order to create isolating mechanisms,

managers need to know the types of necessary resources and the ways of utilizing them. The equifinal, conjunctural, and functionally equivalent nature of the causal factors leading to isolating mechanisms indicates that managers can implement different types of isolating strategies by creating different types of configurations of resources available in their arsenal. As firms can be conceived of as a bundle of heterogeneous resources and capabilities (Amit and Schoemaker, 1993; Mahoney and Pandian, 1992), firms can and sometimes need to implement different types of strategy by allocating resources unique to the firm to achieve the same goal of creating isolating mechanisms. In other words, a firm can take a strategic path that best fits its existing resources and capabilities. This is possible because different combinations of causal factors from each of causal ambiguity and uniqueness would constitute a sufficient condition leading to isolating mechanisms and causal ambiguity and uniqueness from different sources (i.e., intrinsic characteristics of knowledge and geographic scope) are functionally equivalent.

On the one hand, it would be possible to create isolating mechanisms and thus sustain competitive advantage if a firm's knowledge is causally ambiguous and/or unique. On the other hand, it would equally be feasible for the firm to create isolating mechanisms by acquiring knowledge from multiple countries even though the intrinsic characteristics of knowledge are neither causally ambiguous nor unique. More fundamentally, however, the implications of this research study suggest that a firm can achieve the goal of creating isolating mechanisms by selecting a combination of causal factors that best fits its existing resources and capabilities. That is to say, even though a firm is able to increase, for instance, the causal ambiguity or uniqueness from both intrinsic characteristics of knowledge and geographic scope, if the firm has better-developed international presence for knowledge acquisition, then it would be more efficient to create isolating mechanisms by emphasizing geographic scope as a source of causal ambiguity or

unique, while the opposite would also be true for a firm with limited international presence. Indeed, many roads lead to Rome and managers can take the best one for them.

This research study has limitations, which provide interesting avenues for further studies. First, this research study employs the time to first forward citation to operationalize isolating mechanisms. Although studies have shown that the patent citations can be a good proxy for measuring knowledge flow (Jaffe *et al.*, 1993; Singh, 2005) even after controlling for the spurious citations (Jaffe *et al.*, 1998), they do have drawbacks (Song and Shin, 2008). Further studies employing other types of measures or data would validate the arguments advanced in this study and further enrich our understanding on the nature of isolating mechanisms. Second, further studies in the context of other industries than the semiconductor industry could help generalizing the findings. More specifically, further studies in low-tech industries would allow us to better understand whether isolating mechanisms are prominent and effective only in high-tech industries or are generalizable phenomenon across industries with different level of knowledge intensity.

CONCLUSION

This chapter examines the relationship among the causal factors linked to the creation of isolating mechanisms. This research study first discusses geographic scope as an independent source of isolating mechanisms and tests the relationship among the causal factors creating isolating mechanisms employing the fuzzy set QCA method. The empirical findings corroborate the main thesis of this research study that the causal factors leading to isolating mechanisms are equifinal and functionally equivalent in nature. This research study contributes to the literature in at least two ways. First, it provides better understanding of the sources and nature of causal factors linked to the creation of isolating mechanisms. Second, it suggests a new motivation of

firm internationalization, the creation of isolating mechanisms. This research study also provides a managerial implication by highlighting that managers can use different recipes to achieve the same goal of creating isolating mechanisms. Thus, there are many roads leading to Rome.

FIGURES AND TABLES

Table 4.1: Descriptive Statistics and Correlations

	Variables	Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Time to First Forward Citation (in months)	36.97	24.52	1	115	1						
(2)	Tacitness	-4.74	3.07	-29	0	0.04	1					
(3)	Complexity	2.97	1.85	1	13	-0.07	-0.03	1				
(4)	Specificity	-5.61	3.27	-41	-1	0.04	0.09	-0.06	1			
(5)	Originality	0.56	0.27	0	0.93	-0.04	-0.17	0.01	-0.2	1		
(6)	Closedness	-1.24E+12	6.85E+11	-2.57E+12	-7.08E+10	0.04	-0.06	0.05	0.06	-0.01	1	
(7)	No of Countries	2.39	0.9	1	6	0.04	-0.51	-0.05	-0.06	0.17	0.09	1

Table 4.2: Truth Table

Tacitness	Complexity	Originality	Specificity	No of Countries	Closedness	Isolating Mechanisms	Number	Consistency
1	1	0	0	0	0	1	5	0.833
0	1	0	0	1	0	1	4	0.821
1	0	0	1	0	0	1	10	0.817
0	0	0	0	1	0	1	13	0.812
0	0	0	1	1	1	1	4	0.810
0	1	0	1	1	0	1	6	0.801
0	1	1	0	1	1	1	4	0.801
1	1	1	0	0	0	1	6	0.801
1	0	1	1	0	0	0	4	0.797
0	0	0	1	1	0	0	11	0.794
1	0	1	0	0	0	0	7	0.792
1	1	1	1	0	0	0	10	0.791
0	0	1	1	1	1	0	6	0.790
1	0	1	0	1	0	0	7	0.789
0	1	1	0	1	0	0	37	0.770
0	1	1	1	1	0	0	14	0.770
0	0	1	0	1	0	0	44	0.769
0	0	1	1	1	0	0	38	0.767

Note: logical remainders not listed.

Table 4.3: Configurations for Creating Isolating Mechanisms

Causal Conditions	Solutions					
	1	**2a**	**2b**	**3a**	**3b**	**3c**
Intrinsic Characteristics						
Causal Ambiguity: *TACITNESS*		●		●		
Causal Ambiguity: *COMPLEXITY*		●	•		●	
Uniqueness: *SPECIFICITY*	⊗	⊗	⊗	•		
Uniqueness: *ORIGINALITY*	⊗			⊗	⊗	⊗
Geographic Scope						
Causal Ambiguity: *CLOSEDNESS*			●			●
Uniqueness: *NO OF COUNTRIES*	•		•		•	•
Raw Coverage	0.38	0.37	0.31	0.46	0.32	0.38
Unique Coverage	0.01	0.03	0.02	0.05	0.01	0.01
Consistency	0.79	0.76	0.78	0.76	0.76	0.77
Overall Solution Coverage	**0.63**					
Overall Solution Consistency	**0.70**					

Note: ●= core condition (present); ⊗ = core condition (absent); • = peripheral condition (present); ⊗ = peripheral condition (absent); blank space = "don't care" situation (the causal condition may be either present or absent).

Table 4.4: Analyses of Substitutable Necessary Conditions of Hypothesis 2

Conditions	Consistency	Coverage
TACITNESS	0.69	0.65
COMPLEXITY	0.55	0.59
ORIGINALITY	0.75	0.58
SPECIFICITY	0.73	0.62
CLOSEDNESS	0.61	0.69
NOOFCOUNTRIES	0.74	0.62
TACITNESS + CLOSEDNESS	0.79	0.63
COMPLEXITY + CLOSEDNESS	0.75	0.60
ORIGINALITY + NOOFCOUNTRIES	0.87	0.57
SPECIFICITY + NOOFCOUNTRIES	0.88	0.58

CHAPTER 5: ISOLATING MECHANISMS AND VALUE APPROPRIATION

INTRODUCTION

Chapters 3 and 4 show that intrinsic characteristic of knowledge and geographic scope of knowledge acquisition can be an independent source of isolating mechanisms. In addition, Chapters 3 and 4 also show that there exist multiple combinations of the causal factors from the two sources of isolating mechanisms, in which the causal factors from the two sources can play a similar role. In Chapter 5, I examine performance implications of the findings in Chapters 3 and 4, focusing on the value appropriation aspects of geographic scope.

The role of geographic scope of knowledge acquisition or the extent to which a firm acquires its knowledge from multiple countries has attracted attention from scholars investigating innovation. Early studies have found that greater geographic scope of knowledge acquisition positively influences innovation by allowing firms to access diverse knowledge dispersed across countries (Chiesa, 1999; Frost, Birkinshaw, and Ensign, 2002; Nelson, 1993; Schumpeter, 1934). Recent studies, however, have demonstrated that the geographic scope of knowledge acquisition incurs costs as well as benefits (Lahiri, 2010; Singh, 2008). On this basis, these studies maintain that a high level of geographic scope may have negative influences on innovation. The evidence of the negative influences on performance are presented largely with the number of forward citations a patent receives as an indicator of innovation quality (Hall, Jaffe, and Trajtenberg, 2005). These studies submit that the fewer number of forward citations at a high level of geographic scope indicates that other firms have less interest in the innovation from geographically disperse knowledge because they are lower in quality due to the costs incurred.

In this research study, I maintain that the fewer number of forward citations is due in part to the fact that geographic scope of knowledge acquisition creates isolating mechanisms or barriers to imitation (Lippman and Rumelt, 1982; Rumelt, 1984).[18] More specifically, I submit that the innovation from geographically disperse knowledge can be difficult for other firms to imitate because the two distinctive attributes of international markets, *a higher degree of market frictions* and *a higher degree of heterogeneity*, can create isolating mechanisms. Isolating mechanisms would, in turn, impede the flow of knowledge and allow firms to exclude other firms from accessing their innovative knowledge. Consequently, the focal firm is able to capture more value from geographically dispersed innovation of a given quality, thus enjoying better financial performance.

Investigating these points bears important implications. First, it allows us to understand that geographic scope of knowledge acquisition can be a source of *value appropriation*, as well as *value creation*. As a source of isolating mechanisms, geographic scope of knowledge acquisition can help firms not only *create* competitive advantage but also *sustain* the competitive advantage. This new aspect of the role of geographic scope may suggest a new motivation of firm internationalization, *creating* isolating mechanisms and thus *sustaining* competitive advantages. Second, given the dual role of geographic scope, lack of consideration of geographic scope as a source of isolating mechanisms can result in confounding effects on certain types of measures for innovation quality, especially the forward-citation based ones. This point underscores that researchers employing the forward-citation-based measures should be careful to differentiate *motivation* from *awareness* or *capability* of imitating firms. The forward-citation-based approach to innovation quality implicitly assume that firms are *aware* of and *capable* to access the

[18] Isolating mechanisms in this dissertation focus on the impediments to knowledge flow. Therefore, discussion in this dissertation does not include isolating mechanisms by government intervention (e.g., patents and trademarks, legal restrictions on entry (Rumelt, 1984; Somaya, 2003)).

knowledge when they are *motivated* to (Chen, 1996; Chen, Su, and Tsai, 2007; Zhao, 2006). An explicit consideration of isolating mechanisms, however, shows that firms may not be able to access the innovative knowledge even though they are motivated to do so when causal ambiguity and uniqueness, the two factors creating isolating mechanisms, prevent the firms from being aware of the source of superior performance and/or being capable of transferring the knowledge into their boundaries (Hoetker and Agarwal, 2007). Namely, innovative knowledge acquired from broader geographic scope may have fewer forward citations not because of its quality but because of the intrinsic difficulty in imitating the innovative knowledge due to the barriers to imitation created via geographic scope of knowledge acquisition.

Empirical analyses support the main thesis of this chapter. I employ patent- and firm-level data of firms operating in the semiconductor industry and conduct analyses for mediation effects (Baron and Kenny, 1986; MacKinnon, 2008; Shaver, 2005) and moderation effects (Frazier *et al.*, 2004; MacKinnon, 2008). The results show (1) that geographic scope of knowledge acquisition can create isolating mechanisms; (2) that isolating mechanisms created via geographic scope of knowledge acquisition help firms prevent other firms from accessing their innovative knowledge; and (3) that isolating mechanisms help firms capturing a larger proportion of economic returns from innovation, thus helping them enjoy better financial performance. These findings highlight the value appropriation aspect of geographic scope and the role of isolating mechanisms in helping firms more exclusively capture the value they create through innovation.

This research study contributes to the literature in at least three ways. First, it suggests a broader range of factors to be considered as sources for isolating mechanisms. This research study demonstrates that, in addition to the barriers that arise due to intrinsic characteristics of knowledge such as tacitness, complexity, and specificity, the geographic scope of knowledge acquisition can be an *independent* source of isolating mechanism. This finding suggests that

different types of viable strategies can be employed to create isolating mechanisms and thus to sustain competitive advantages by utilizing firms' resources and capabilities in multiple dimensions including intrinsic characteristics of knowledge and geographic scope of knowledge acquisition.

Second, this research study introduces the value appropriation aspect of geographic scope. While extant literature highlights the *value creation* aspect of geographic scope, this research study complements the extant studies by demonstrating that geographic scope of knowledge acquisition can be a source of the *value appropriation* by creating isolating mechanisms. The value appropriation aspect of geographic scope, in turn, introduces a new motivation of firm internationalization, *sustaining competitive advantages via creation of isolating mechanisms*. The existing literature has largely focused on creating value thus generating competitive advantages by either *exploiting* firm-specific advantages in international markets (Dunning, 1988; Hymer, 1960/1976) or *exploration* of new strategic resources (Makino *et al.*, 2002; Moon and Roehl, 2001) as a motivation of firm internationalization. In addition to generating competitive advantages, findings of this research study suggest that firms may also be motivated to internationalize their operations to create isolating mechanisms thus sustain their competitive advantages, by strategically leveraging the unique attributes of international markets.

Lastly, this research study advances our understanding of the nature of the forward-citation-based measures for innovation quality by contrasting different drivers to forward citations. Forward citations are driven not only by the *motivation* to cite due to the quality of a patent but also by the *awareness* and *capability* to cite due to isolating mechanisms. Given these multiple drivers to forward citations, failure to take into consideration the role of isolating mechanisms in influencing forward citations would result in a confounding understanding of innovative outputs. Showing possible mediating effects of isolating mechanisms on the relationship between

geographic scope and innovation quality operationalized as forward-citation-based measures, this research study suggests that studies employing the number of forward citations a patent receives or the number of patents weighted by the number of forward citations need to pay special attention to possible mediating effects of isolating mechanisms.

THEORY AND HYPOTHESES

Geographic Scope and Innovation Output

Studies on the relationship between geographic scope and innovation output have employed different types of measures for innovation output: *the number of patents* (Penner-Hahn and Shaver, 2005) and *the number of forward-citations a patent receives* (Lahiri, 2010; Singh, 2008). Recent studies show that geographic scope can have a negative association with innovation quality measured as the number of forward citations or the number of patents weighted by the number of forward citations (Lahiri, 2010; Singh, 2008). The rationales behind the negative association are that the costs outweigh the benefits from accessing pockets of excellence across the world (Chiesa, 1999). These costs includes search costs for the right knowledge (Sorenson and Stuart, 2001), challenges in transferring knowledge (Hansen and Løvås, 2004), and difficulties in coordinating and integrating the diverse knowledge (Grant, 1996). In line with the findings in the extant literature, I hypothesize as a base-line hypothesis that geographic scope of knowledge acquisition would have a negative relationship with the number of forward citations a patent receives when employed as a measure for innovation quality.

Hypothesis 5.1: **[Geographic Scope and Number of Forward Citations]** The greater the geographic scope in a patent's backward citations, the fewer the number of forward citations a patent receives.

Geographic Scope and Meditating Effects of Isolating Mechanisms

As discussed, recent studies found a negative association between geographic scope of knowledge acquisition and innovation quality measured with the number of forward citations. However, possible mediating effects of isolating mechanisms created by geographic scope of knowledge acquisition have not been taken into consideration yet. This could be misleading because isolating mechanisms created by geographic scope could make it difficult for other firms to cite new patents, even though the patents are good in quality and thus the imitating firms are motivated to do so (Chen, 1996; Chen *et al.*, 2007; Zhao, 2006). In other words, if geographic scope could create isolating mechanisms, a part of the negative association between geographic scope of knowledge acquisition and the number of forward citations can be attributed to the difficulties in citing the patents due to the protection from isolating mechanisms. In this section, I discuss first how the geographic scope of knowledge acquisition can create isolating mechanisms and then how the isolating mechanisms can reduce the number of forward citations. On the basis of the discussion, I develop hypotheses on the mediating effects of isolating mechanisms on the relationship between geographic scope of knowledge acquisition and the number of forward citations.

Two Attributes of International Markets

Firms can acquire knowledge from domestic markets (i.e., a single country) and/or from international markets (i.e., multiple countries). When compared with domestic markets, international markets have two distinctive attributes: *a higher degree of market frictions* and *a higher degree of heterogeneity*.

First, international markets can provide a higher degree of market frictions than domestic markets. Countries differ in cultural, administrative/political, geographic, and economic

dimensions (Ghemawat, 2001, 2003, 2007) and, due largely to these differences, firms investing abroad can experience much higher market frictions than those in domestic markets. These market frictions, in turn, give rise to multiple layers of uncertainty (Miller, 1992), information asymmetry (Arrow, 1974), and lack of legitimacy, local knowledge, and relationships in host countries (Chan and Makino, 2007; Zaheer, 1995), which incurs additional costs of doing business or liability of foreignness (Dunning, 1998; Hymer, 1960/1976; Teece, 1981b; Vernon, 1966; Zaheer, 1995) and the liabilities of outsidership from relevant networks (Johanson and Vahlne, 2009). Sources of liability of foreignness include differences in communication and government discrimination (Hymer, 1960/1976), spatial distance, unfamiliarity with a local environment, lack of legitimacy of foreign firms, and (possible) economic nationalism (Zaheer, 1995).

Second, international markets can provide a higher degree of heterogeneity than domestic markets. Firms acquiring knowledge abroad can enjoy greater sources of diverse resources and capabilities than those acquiring only from domestic markets. In other words, acquiring knowledge from multiple countries would provide a higher degree of heterogeneity than acquiring from only a single country. Countries differ from each other (Ricart *et al.*, 2004) in terms of not only factor endowments but also socio-political institutions and cultural aspects (Brouthers *et al.*, 2008; Cheng, 1994; Henisz and Macher, 2004; Kristensen and Zeitlin, 2005). Countries also differ from each other in their technological and organizational principles (Kogut, 1991) and systems of innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993).

In addition to the country differences, firms are embedded in the countries they are operating in and are influenced by the characteristics of the countries' knowledge. Firms are embedded in the location of the firms' operation in terms of resources and capabilities (Collis, 1991; Dunning, 1998; Kogut, 1991; Porter, 1990, 1998; Shan and Hamilton, 1991), historically

determined political and economic conditions or institutions (Hamilton and Biggart, 1988), and social relationships (Granovetter, 1985). The country difference and firms' embeddedness provide different types of prior knowledge and, thus, create a unique knowledge corridor to the firms operating in a country (Shane, 2000). More specifically, information available in each country shapes and drives different types of entrepreneurial opportunity and discovery (Fabrizio and Thomas, 2012; Ma, Huang, and Shenkar, 2011; Shane, 2000; Von Hayek, 1945), generating different types of knowledge in each country, thus resulting in country as a distinctive knowledge set. As established in the studies of national systems of innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993), firms across countries pursue different approaches to innovation (Whitley, 2000) and produce different patterns of technological development (Lam, 2003; Lehrer and Asakawa, 2003) due largely to variations in institutional characteristic across countries, patterns of local demand, firms' embeddedness in the national systems of innovation, and heterogeneity in the administrative heritage of firms (Fabrizio and Thomas, 2012; Lam, 2003; Lehrer and Asakawa, 2003; Whitley, 2000). As such, characteristics of knowledge tend to be relatively more homogeneous among the firms within a country but relatively more heterogeneous among the firms across countries.

Geographic Scope as a Source of Isolating Mechanisms

Each of the two attributes of international markets, *a higher degree of market frictions* and *higher degree of heterogeneity*, is associated with causal ambiguity and uniqueness, the two factors creating isolating mechanisms, and thus can be a source of isolating mechanisms. First, a higher degree of market frictions could increase causal ambiguity. As discussed in the attributes of international markets, the multiple layers of uncertainty, information asymmetry, and lack of legitimacy in foreign countries can increase the degree of causal ambiguity for the knowledge

acquired from foreign countries, thus making it much harder to figure out the sources of superior performance. Second, a higher degree of heterogeneity could increase uniqueness. Again as discussed in the attributes of international markets, characteristics of knowledge tend to be relatively more homogeneous within a country but relatively more heterogeneous across countries. As such, acquiring knowledge from multiple countries would allow a focal firm to have a less redundant and thus more unique combination of knowledge, which would increase factor immobility. In this way, the two attributes of international markets increase causal ambiguity and uniqueness and thus create isolating mechanisms.

An effect of isolating mechanisms can manifest itself in the increase in time to imitation (Zander and Kogut, 1995). Although knowledge tends to leak despite efforts to prevent it from doing so (Almeida and Kogut, 1999; Jaffe *et al.*, 1993), the rate of leakage is slower when the knowledge is isolated because the imitation requires greater efforts than otherwise (Hoetker and Agarwal, 2007). As such, if a patent contains hard-to-imitate knowledge, then it could take longer for other firms to cite the patent. This discussion leads to the following hypothesis.

Hypothesis 5.2a: **[Geographic Scope and Isolating Mechanisms]** The greater the geographic scope in a patent's backward citations, the longer it takes for other firms to cite that patent.

Isolating Mechanisms and Innovation Output

Isolating mechanisms impede flow of knowledge, which would make the creation of new production function uncertain (Lippman and Rumelt, 1982) and thus eventually make it difficult to imitate the knowledge. Studies have demonstrated that the patent citations can be a good proxy for measuring knowledge flow. Patent citations show the trails of new knowledge creation (Singh, 2005) because "a citation of Patent X by Patent Y means that X represents a piece of

previously existing knowledge upon which Y builds" (Jaffe *et al.*, 1993: 580). Although patent citations are not a perfect measure of knowledge flow, empirical studies show that they are a valid measure of knowledge flow (Jaffe *et al.*, 1998). Therefore, we can expect that a patent that is protected by a high level of isolating mechanisms would receive fewer citations by other firms (Alcácer and Zhao, 2012). This discussion leads to the following hypothesis.

Hypothesis 5.2b: **[Isolating Mechanisms and Number of Forward Citations]** The longer it takes for other firms to cite a patent, the fewer the number of forward citations a patent receives.

Meditating Effect of Isolating Mechanisms

Foregoing discussion highlights 1) that geographic scope of knowledge acquisition can create isolating mechanisms; and 2) that isolating mechanisms can impede flow of knowledge. These causal links elucidate that isolating mechanisms can *mediate* the relationship between geographic scope of knowledge acquisition and innovation. That is, unlike the viewpoints of the extant literature that exclusively approach from the *value creation* perspective the relationship between geographic scope of knowledge acquisition and the number of forward citations a patent receives, the foregoing discussion suggests that geographic scope of knowledge acquisition can also be a source of *value appropriation* by creating isolating mechanisms thus making it difficult for other firms to cite the patents. Indeed, a patent may receive less (or more) forward citations due not only to its quality but also to the difficulties to cite that patent. More specifically, a patent may not receive forward citations if would-be citing firms are not *motivated* to do so because of the low quality of the patent. It is, however, equally possible that the would-be citing firms cannot do so because they are not *aware* of the patent due to causal ambiguity toward the source of the superior performance or they have are not *capable* to do so due to the uniqueness of

innovative knowledge. Given that organizational actions are based on the three essential factors of awareness-motivation-capability (Chen, 1996; Chen *et al.*, 2007), *motivation* alone may not explain the entire variance in the number of forward citations a patent receives, which consequently suggests that there can exist multiple causal paths leading to the number of forward citations. As such, a *part* of the number of forward citations of a patent generated by integrating knowledge dispersed across countries can be explained by the *mediating* effects of isolating mechanisms created by geographic scope of knowledge acquisition. Therefore, we can expect that isolating mechanisms created by geographic scope of knowledge acquisition can *partially* mediate the relationship between geographic scope and innovation quality. This discussion leads to the following hypothesis.

Hypothesis 5.2c: **[Mediating Effect of Isolating Mechanisms]** The increase in time for other firms to cite a focal firm's patents would *partially* mediate the influences of the extent of geographic scope in a patent's backward citations on the number of forward citations a patent receives.

Isolating Mechanisms and Financial Performance

The discussion on the mediating effects implies that geographic scope of knowledge acquisition can be a source of value appropriation by excluding other firms from accessing the innovative knowledge and thus help focal firms enjoy more room to exclusively capture the value created through their innovation activities. Firms often face difficulties in capturing values they created due to the nature of knowledge that tends to diffuse (Almeida and Kogut, 1999; Jaffe *et al.*, 1993) and subsequent expropriation by competitors (Liebeskind, 1996; Teece, 1986). In this light, value appropriation is a necessary condition for good financial performance and a firm needs a device to appropriate the value they created through the innovation process (Teece,

1986). Impeding the flow of knowledge and thus preventing imitation by competitors, isolating mechanisms help a focal firm prevent its competitors from accessing the innovative knowledge and enjoy more room to capture a larger proportion of the value it created through the innovative activates. Therefore, if knowledge in a focal firm's patents is protected by isolating mechanisms and thus it takes longer for other firms to cite the patents, the focal firm could enjoy an extended period of time to exclusively appropriate the economic returns from innovation. This implies that the marginal effect of innovation quality on financial performance would be greater due to the better appropriation of the economic returns from innovation. This discussion leads to the following hypothesis.

Hypothesis 5.3: **[Isolating Mechanism and Financial Performance]** The longer it takes for other firms to cite a focal firm's patents, the more positive the effect of innovation quality on financial performance.

Table 5.1 lists hypotheses and their classification. Figure 5.1 illustrates the relationships between constructs and expected signs of each hypothesis.

DATA AND METHODOLOGY

Sample

Hypotheses are tested with patent data in the semiconductor industry (SIC: 3674 Semiconductors and Related Devices) applied to USPTO during the 10-year period of 1992-2001. This research setting is appropriate to test the hypotheses because first the semiconductor industry is a representative high-tech industry with rapid technological progress and a well-established global standard and presence (Almeida, 1996; Breznitz, 2007; Henisz and Macher,

2004; Ziedonis, 2004) and second it controls for possible influences from industry structure (Ahuja *et al.*, 2008).

Due to the nature of research questions, hypotheses are tested at two different levels of analyses. First, Hypotheses 5.1-5.2 are tested with at the patent level with 33,204 patents as they address the relationship among the patent-specific characteristics. The patent data are retrieved from the 2006 edition of the NBER patent data. Second, Hypothesis 5.3 is tested at the firm level with data of 35 firms operating in the semiconductor industry because the nature of the question is on the firm-level performance. As Hypothesis 5.3 tests the moderating effects of isolating mechanisms on the relationship between firm-level innovation and financial performance, patent-level variables employed to test Hypotheses 5.1-5.2 are averaged into the firm-year level when testing Hypothesis 5.3 (Rosenkopf and Nerkar, 2001; Wang and Chen, 2010). Data from Standard & Poor's *Compustat* database are also employed for the firm-level financial performance measures and control variables.

Variables

Hypothesis 5.1

Hypothesis 5.1 tests the relationship between geographic scope and innovation quality. The dependent variable for Hypothesis 5.1 is innovation quality and is operationalized as the number of forward citation a patent receives in line with the extant studies (Argyres and Silverman, 2004; Henderson, Jaffe, and Trajtenberg, 1998; Singh, 2008). In order to address possible truncation bias, I specify a five-year window from the application year when calculating the number of forward citations (Lahiri, 2010). The independent variable for Hypothesis 5.1 is geographic scope of knowledge acquisition and is operationalized as the number of assignee countries found in the backward citations of a new patent.

As control variables, I control for the patent characteristics of originality, the number of claims in a patent, the number of International Patent Classification (IPC) classes, and the number of patents in backward citations. The originality of a patent captures the extent to which a focal patent draws upon a wide range of technological fields and can be measured for a patent *i* as follows (Jaffe and Trajtenberg, 2002):

$$Originality_i = 1 - \sum_{k=1}^{N_i} \left(\frac{NCITED_{ik}}{NCITED_i}\right)^2$$

where *k* represents the index of patent class, N_i the number of different classes to which the cited patents belong, and *NCITED* the number of patents cited by the focal patent. The number of claims is measured as a total number of claims made in a new patent and captures the technological space being protected by the patent (Lanjouw and Schankerman, 1997). The number of IPC classes is measured as the total number of IPC classifications of a new patent and capture the scope of the patent (Harhoff *et al.*, 2003; Lerner, 1994). The number of patents in backward citations is measured as the number of citations to prior art (i.e., the number of backward citations in a new patent) (Harhoff *et al.*, 2003). Dummies for year are included to control for possible year-effects.

Hypothesis 5.2a

Hypothesis 5.2a tests the relationship between geographic scope and isolating mechanisms. The dependent variable in Hypotheses 5.2a is the degree of isolation. Following Zander and Kogut's (1995) study on the speed of the transfer and imitation of organizational capabilities, the degree of isolating mechanisms is constructed as the extent to which a patent is isolated from imitation and it is operationalized as the time to the first forward citation by other firms. Time to first forward citation is measured by the length of time, in years, between the patent application and the first forward citation by other firms to the patent. In line with Hypothesis 5.1, the

independent variable for Hypothesis 5.2a is geographic scope of knowledge acquisition and is operationalized as the number of assignee countries found in the backward citations of a new patent.

As control variables, all the patent characteristics variables employed to test Hypothesis 5.1 are also used. In addition, I also specify a patent's membership in the Triadic Patent Families (TPF) as a control for the quality of the patent, which can have a significant influence on the speed of patent citation. Membership in TPF is measured as a binary variable and classifies each patent's membership in the '*OECD, Triadic Patent Families database, June 2010'*. The Triadic Patent Families are a list of patents that are filed at the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO), *and* the Japan Patent Office (JPO). This variable allows us to assess the quality of patents: as filing patents in the multiple patent offices incurs non-trivial costs, firms have incentive to protect only those patents worth the costs (Martínez, 2011). In this light, this variable represents a focal firm's *perception* of the quality of the patent. Therefore, we can expect that patents with membership in TPF are higher in quality (Harhoff *et al.*, 2003; Lanjouw and Mody, 1996; Sapsalis *et al.*, 2006). In addition, Membership in TPF also allows us to mitigate the 'home advantage' effect, a home-country bias toward the propensity of patent filing. As patents are in most cases first filed in the home country of inventors, national patent offices have disproportionally large number of patents filed by domestic applicants. This effect can distort the degree of domestic innovation in a particular country and raises issues when patent data are used for international comparison (Criscuolo, 2006; Martínez, 2011).

Hypothesis 5.2b

Hypothesis 5.2b tests the relationship between isolating mechanisms and the number of forward citations. In line with Hypothesis 5.1, the dependent variable for Hypotheses 5.2b is the

number of forward citation a patent receives. The independent variable in Hypothesis 5.2b is the time to first forward citation measured by the length of time, in years, between the patent application and the first forward citation by other firms to the patent. This variable is employed as a dependent variable in the test of Hypothesis 5.2a. The same set of control variables used for testing Hypothesis 5.1 is also employed.

Hypothesis 5.2c

Hypothesis 5.2c tests the mediating effects of isolating mechanisms created by geographic scope of knowledge acquisition. This test uses the results from Hypotheses 5.2a and 5.2b. Specific methods of the test are discussed in the methodology section of this chapter.

Hypothesis 5.3

Hypothesis 5.3 tests the moderating effects of isolating mechanisms on the relationship between innovation quality and financial performance. The dependent variable for Hypothesis 5.3 is financial performance of a firm. I operationalize the financial performance with return on assets (ROA) in its natural logarithm form as a measure of firms' profitability (Hitt, Hoskisson, and Kim, 1997; Kotabe, Srinivasan, and Aulakh, 2002). I specify one-year time lag between independent variables and dependent variables in order to incorporate into the analysis the time taken for the innovation to be realized in financial performance. The independent variable for Hypotheses 5.3 is innovation quality. In line with Hypotheses 5.1-5.2, I operationalize innovation quality as the number of forward citations a patent receives, which is calculated as an annual average of the number of forward citations to the patents of a focal firm. This variable is an aggregation to the firm-year level of the dependent variable employed for Hypotheses 1 and 2b. The moderating variable in Hypothesis 5.3 is the degree of isolation. For this, I average the time to first forward citation used in Hypotheses 5.2a and 5.2b over the firm-year level.

For control variables, I average the patent-level control variables employed in Hypotheses 5.1-5.2 over the firm-year level. I also include annual counts of patent applications by firms (No of Patents). This measure has been used as an indicator of innovation productivity (Hitt, Hoskisson, Ireland, and Harrison, 1991; Makri, Hitt, and Lane, 2010; Mowery, Oxley, and Silverman, 1998). In addition, I also control for firm-level variables that can influence firm performance, such as R&D intensity, advertising intensity, firm size, firm leverage, and product diversification. R&D intensity is measured as the natural logarithm of R&D expenses divided by assets. Advertising intensity is measured as natural logarithm of advertising expenses divided by assets. Firm size is measured as natural logarithm of total assets. Firm leverage is measured as the ratio of a firm's long-term debt to its total assets. In order to control the influence from the degree of firm diversification (Palich, Cardinal, and Miller, 2000), I employ an entropy measure of product diversification (Palepu, 1985) measured as follows:

$$Product\ diversification = \sum_{i=1}^{N} P_i \ln (1/P_i)$$

where P_i is the share of the i^{th} segment in the total sales of the firm. Four-digit SIC codes are used as segments. Dummies for year are included to control for year-effects.

Methodology

Due to the characteristics of different dependent variables, hypotheses are tested with multiple statistical techniques. First, as the dependent variable for innovation quality operationalized as the number of forward citations is a count variable, the family of count data models is considered for Hypotheses 5.1 and 5.2b (Greene, 2007). Count variables can be estimated through the Poisson process as follows:

$$\ln(\boldsymbol{\mu}) = \boldsymbol{X\beta}$$

where $\boldsymbol{\mu}$ is a mean value matrix parameterized in terms of $\boldsymbol{X}$, the covariate matrix, and $\boldsymbol{\beta}$, the coefficient vector. The Poisson distribution, however, assumes that the mean equals the variance, which may not be a reasonable assumption. Unlike the Poisson distribution, the negative binomial distribution relaxes the assumption of the Poisson distribution and allows the variance to exceed the mean (Cameron and Trivedi, 1998). Therefore, Hypotheses 5.1 and 5.2b on the effects of geographic scope and isolating mechanisms on the number of forward citations are tested with the negative binomial regressions.[19] I also specify the clustered sandwich estimator for the variance in order to account for possible non-independence among the observations within a firm (Greene, 2007; White, 1980). A negative coefficient of Number of Countries and Time to First Forward Citation would support Hypotheses 5.1 and 5.2b, respectively.

Second, in order to estimate the effects of covariates on the time to the first forward citation, the test on the relation between geographic scope of knowledge acquisition and isolating mechanisms (i.e., Hypothesis 5.2a) employs an accelerated failure-time (AFT) model (Cox and Oakes, 1984; Kalbfleisch and Prentice, 1980) with the following specification:

$$\ln(\boldsymbol{T}) = \boldsymbol{X\beta} + \sigma\boldsymbol{\varepsilon}$$

where $\ln(\boldsymbol{T})$ is a natural logarithm of the time to the first forward citation, $\boldsymbol{X}$ is a covariate matrix, $\boldsymbol{\beta}$ is a coefficient vector, σ is the scale parameter, and $\boldsymbol{\varepsilon}$ is a vector of error terms that follow Weibull distribution. In order to control for unobservable firm level heterogeneity, I also employ the shared frailty model (Gutierrez, 2002; Hougaard, 1984), which is a survival model analog of a random effect model, by specifying patent applicant *i* to share the same frailty. A

[19] The number of forward citations variable violates the assumption of the Poisson distribution that $E(Y) = \text{Var}(Y) = \mu$ implying the existence of over-dispersion. A likelihood-ratio test of "H_0: alpha = 0" is statistically significant ($p < 0.00$), supporting that the negative binomial model fits the data better.

positive coefficient of Number of Countries indicates longer time to the first forward citation by others and thus would support Hypothesis 5.2a.

Hypothesis 5.2c tests the mediation effects of isolating mechanisms (Baron and Kenny, 1986; MacKinnon, 2008; Shaver, 2005). Meditating effects explain "the effect by the causal sequence from the independent variables to the mediator to the dependent variable" (MacKinnon, 2008: 8). Baron and Kenny's (1986) causal steps approach, the most widely used method to assess the existence of mediation (MacKinnon, 2008; Wood, Goodman, Beckmann, and Cook, 2008), suggests three conditions for mediating effects to exist. First, the independent variable should have a statistically significant influence on the mediating variable. Second, the mediating variable should have a statistically significant influence on the dependent variable. Third, the statistical significance of a previously significant relationship between the independent variable and the dependent variable reduces after controlling for the effects of the mediating variable (Baron and Kenny, 1986: 1176). If the statistical significance of the independent variable's influence on the dependent variable does not reduce to zero, it implies existence of multiple mediating factors (Baron and Kenny, 1986: 1176) and thus partial mediation (James, Mulaik, and Brett, 2006), which is more realistic in social science (Baron and Kenny, 1986: 1176). Regarding the third condition, MacKinnon (2008: 9) maintains that "it is possible that there is a significant meditational process even if there is not a significant overall relation between the independent variable and the dependent variable" Indeed, simulation studies have shown that two of the most important criteria for mediating effects are the significant relationships 1) between the independent variable and the mediating variable; and 2) between the mediating variable and the dependent variable (MacKinnon, 2008; Mackinnon, Lockwood, Hoffman, West, and Sheets, 2002). In the case of this study, these correspond to the significant relationships 1) between the geographic scope and isolating mechanisms; and 2) between isolating mechanisms and the

number of forward citations, each of which corresponds to Hypotheses 5.2a and 5.2b, respectively. Therefore, a positive coefficient of Number of Countries in Hypothesis 5.2a and a negative coefficient of Time to First Forward Citation in Hypothesis 5.2b would support Hypothesis 5.2c that isolating mechanisms would *partially* mediate the relationship between geographic scope of knowledge acquisition and the number of forward citations.

In terms of measuring the effect size of mediation, however, traditional approaches would not be appropriate, because the non-linear specifications due to the nature of the dependent variable (i.e., the number of forward citations) requires a special consideration when calculating the size of the mediation effect (MacKinnon, 2008). In order to properly address methodological issues arising from the non-linear nature of the regression specifications, I employ a quasi-Bayesian Monte Carlo approximation method to estimate causal mediation effects recently suggested by Imai and colleges (Imai *et al.*, 2010a; Imai *et al.*, 2010b, 2011). This approach generalizes the traditional methods and accommodates linear and non-linear relationships, thus allowing me to address the methodological issues in estimating mediation effects.

Lastly, in order to control for unobserved firm-specific heterogeneity (Greene, 2007), Hypothesis 5.3 on the moderating effect of isolating mechanisms on the relationship between innovation quality and firm performance is tested with firm-level random-effect panel regression models with the following specification for firm *i* in year *t*:

$$\begin{aligned} Financial\ Performance_{it+1} &= \beta_0 + \beta_1 Innovation\ Output_{it} \\ &+ \beta_2 Isolating\ Mechanisms_{it} \\ &+ \beta_3 Innovation\ Output_{it} \times Isolating\ Mechanisms_{it} \\ &+ \beta_{4\sim14} Control\ Variables_{it} + \varepsilon_{it} \end{aligned}$$

where ε_{it} denotes an error term for firm *i* in year *t*.[20] A positive and statistically significant β_3 would support the hypothesis.

RESULTS

Hypotheses 5.1-5.2

Panels (a) and (b) in Table 5.2 list descriptive statistics and correlations for the variables employed in testing the patent (i.e., Hypotheses 5.1-5.2) and firm level hypotheses (i.e., Hypothesis 5.3), respectively. Table 5.3 lists the results for the test of Hypotheses 5.1-5.2. Model 1 shows that the coefficient for Number of Countries is negative (β = -0.0391) and statistically significant (p = 0.025), showing, in line with existing literature, that geographic scope of knowledge acquisition has a negative relationship with innovation quality measured with the number of forward citations (X→Y).[21] Therefore, Hypothesis 5.1 is supported.

Model 2, the AFT model for Hypothesis 2a (X→M), shows that the coefficient for Number of Countries is positive (β = 0.00992) and statistically significant (p = 0.002), thus supporting Hypothesis 5.2a. In addition, statistically significant and positive coefficient of Number of Countries after controlling for the variables measuring intrinsic characteristics of knowledge such as Originality and Number of IPC corroborates the argument that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms.

In Model 3, the negative binomial model for Hypothesis 5.2b (M→Y), the coefficient for Time to First Forward Citation is negative (β = -0.480) and statistically significant ($p < 0.001$), thus corroborating Hypothesis 5.2b.

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[20] The random-effects panel specification is more appropriate, because Hausman's (1978) tests do not reject the null hypothesis that the random effect estimator is consistent. (p = 0.8873).

[21] Each of X, M, and Y denotes notations representing X: the independent variable; M: the mediating variable; Y: the dependent variable.

These results support the existence of *partial* mediation by isolating mechanisms on the relationship between geographic scope of knowledge acquisition and the number of forward citations (MacKinnon, 2008: 68-70). First, statistically significant results for each of Hypotheses 5.1, 5.2a, and 5.2b support the first three steps of Baron and Kenny's (1986) causal steps approach. Second, the increase in the value of the coefficient for Number of Countries from -0.0391 in Model 1 to -0.0307 in Model 4 after controlling for the effect of Time to First Forward Citation in Model 4 also shows the existence of *partial* mediation: a part of the negative effect of Number of Countries is mediated by Time to First Forward Citation (James *et al.*, 2006). Table 5.4 shows the results of estimation of mediation effects. The isolating mechanisms have a statistically significant mediation effect of -0.003904 as its 95% quasi-Bayesian confidence intervals does not include zero. Therefore, Hypothesis 5.2c is supported. The table also shows that 12.02% of the total effect of No of Countries on No of Forward Citations is mediated by Time to First Forward Citation. Figure 5.2 graphically illustrates the mediation effects with 95% quasi-Bayesian confidence intervals.

Hypothesis 5.3

Table 5.5 lists the results for moderating effects of isolating mechanisms. Model 1 in Table 5.5 shows the random-effect panel regression result with only control variables. Model 2 lists the results of main effects of No of Forward Citations and Time to First Forward Citation without interactions. Model 3 shows the interaction to test the moderating effect of isolating mechanisms derived in Hypothesis 5.3. As predicted, the interaction term between No of Forward Citations and Time to First Forward Citation shows a positive (β = 0.0092) and statistically significant coefficient (p = 0.006), showing that the marginal effect of No of Forward Citations on financial

performance would increase by 0.0092 as Time to First Forward Citation increases by one unit. Therefore, Hypothesis 5.3 is supported.

Figure 5.3 illustrates the moderating effects of isolating mechanisms on the relationship between innovation quality and financial performance measured as ln(ROA). Panel (a) depicts that an increase in No of Forward Citations would have a negative relationship with ln(ROA) when Time to First Forward Citation is low (or at mean - 2SD), while a positive relationship when Time to First Forward Citation is high (or at mean + 2SD). Panel (b) of Figure 3 illustrates at 95% confident interval that one unit increase No of Forward Citations would *decrease* ln(ROA) when Time to First Forward Citation is below 0.5. However, one unit increase in No of Forward Citations would *increase* ln(ROA) when Time to First Forward Citation is around 2 and above.

The moderating effects of isolating mechanisms can be more effectively demonstrated in a 3-dimensinoal space as illustrated in Panel (a) of Figure 5.4 and in a contour graph in Panel (b) where the numbers on the isolines represent the values of ln(ROA). First, when Time to First Forward Citation is 1 year (which is around 2 standard deviation *below* the mean, thus a *low* level of isolating mechanisms), increasing No of Forward Citations would decrease ln(ROA), while the opposite would be true when Time to First Forward Citation equals 3 years (which is around 2 standard deviation *above* the mean, thus a *high* level of isolating mechanisms). These findings demonstrate the *benefits* of isolating mechanisms in value appropriation. Second, however, when No of Forward Citations is as low, for instance, as 1, increasing Time to First Forward Citation would decrease ln(ROA), while the opposite would be true when No of Forward Citations is as high, for instance, as 35. These findings indeed highlight the *costs* associated with isolating mechanisms as value appropriation devices. Third, the areas along the diagonal line in Panel (b), which correspond to the ridge line in Panel (a) of Figure 4, can provide positive and increasing financial performance. These findings underscore the importance

of value appropriation on financial performance. That is, increases in the quality of innovation output should be accompanied with increasing protection of the innovative knowledge in order to capture the economic returns from innovation.

Robustness Checks

The results are robust across different model specifications. First, specification of the Poisson distribution for the regressions with the dependent variable of count data also shows consistent results with the negative binomial specifications. Second, log-normal, log-logistic, and exponential distribution specifications for the distributions of AFT models yield consistent results with the Weibull specification. Third, fixed-effect specifications for the panel regressions also yield consistent results with the random-effect specifications.

I also check the robustness of findings for Hypothesis 5.3 with two additional dependent variables. First, return on R&D expenses (RORD) in its natural logarithm form is also calculated in a similar way with ROA to capture more directly the productivity or input-to-output aspect of the economic return from innovation (Ahuja *et al.*, 2008). Second, net profit margin in its natural logarithm form is employed to measure firms' profitability. This measure is useful to compare corporate performance in the same industry (Jiang, Tao, and Santoro, 2010; Min and Wolfinbarger, 2005). Regressions with ln(RORD) and ln(net profit margin) as dependent variables show similar results with ln(ROA) as the dependent variable. The results of the robustness checks are reported in Table 5.6.

DISCUSSION AND CONCLUSION

This chapter examines the value appropriation aspect of geographic scope, focusing on the meditating and moderating effects on innovation and financial performance of isolating

mechanisms created through geographic scope of knowledge acquisition. This research study posits that geographic scope of knowledge acquisition can create isolating mechanisms and maintains (1) that isolating mechanisms created via geographic scope of knowledge acquisition help firms prevent competitors from accessing their innovative knowledge; and (2) that isolating mechanisms help firms capturing a larger proportion of economic returns from innovation, thus helping them enjoy better financial performance. The results of empirical analyses with data in the semiconductor industry corroborate the main thesis that geographic scope of knowledge acquisition can create isolating mechanisms and in turn help firms more exclusively appropriate the economic returns from innovation by mediating and moderating the relationship between geographic scope and firm performance.

The empirical support for the mediating and moderating effects of isolating mechanisms underscore the value appropriation aspect of geographic scope of knowledge acquisition. First, the mediating effects of isolating mechanisms demonstrate that geographic scope of knowledge acquisition can help firms prevent other firms from accessing their innovative knowledge. Second, the moderating effects of isolating mechanisms on the relationship between innovation quality and financial performance elucidate that firms can enjoy better financial performance out of given quality of innovation when their innovative knowledge is protected by isolating mechanisms. In fact, each of mediating and moderating effects of isolating mechanisms shows the process of value appropriation. First, the mediating effects show the prerequisite of value appropriation in that "value appropriation presupposes that the owner can *exclude* non-owners from using or destroying attributes to which he holds property right" (Foss and Foss, 2005: 544). Second, the moderating effects show the consequence of the exclusion. By excluding other firms from accessing the innovative knoweldge, firms can enjoy more room to exclusively capture the economic returns from innovation of given quality and thus achieve better financial perforamnce.

Through this process, geographic scope of knoweldge acquisition can be a source of value appropriation.

This research study provides an important implication with regards to the role of geographic scope in influencing financial performance. Studies have found a positive association between financial performance and the number of forward citations a patent receives that captures the innovation quality of the patent. More specifically, Hall and colleagues (2005) find a 3% increase in market value of the firm with an extra citation per patent. From this perspective, in line with the extant studies, geographic scope of knowledge acquisition may seem to exert negative influences on financial performance: it decrease the number of forward citations (Singh, 2008), which could in turn decrease firms' market value (Hall *et al.*, 2005). As highlighted in this research study, however, there can exist at least two causal mechanisms influencing the number of forward citations, each of which illuminates different aspects of geographic scope of knowledge acquisition: *value creation* and *value appropriation*. On the one hand, from the *value creation* perspective, in line with the foregoing discussion, geographic scope of knowledge acquisition can indeed have a *negative* influence on financial performance by lowering the innovation quality. On the other hand, from the *value appropriation* perspective, the fewer number of forward citations due to geographic scope of knowledge acquisition could actually be good news to a focal firm. First, it implies that the innovative knowledge is protected by isolating mechanisms. Second, the protection from isolating mechanisms would in turn enable the focal firm to more exclusively capture the economic return from innovation. In other words, fewer citations and better financial performance due to isolating mechanisms created by geographic scope of knowledge acquisition indeed imply that geographic scope of knowledge acquisition from the value appropriation perspective can have a *positive* influence on financial performance. Although cited fewer, it is not because of the quality of the patent but because of the

impediments to knowledge flow due to isolating mechanisms, which at the same time enable the focal firm to enjoy better financial performance. In sum, it is important to note that geographic scope of knowledge acquisition can exert a positive influence on financial performance, as well as negative one. More importantly, this finding suggests that managers need to differentiate different aspects of geographic scope of knowledge acquisition in influence financial performance and implement knowledge acquisition strategy accordingly.

This research study contributes to the research literature in at least three ways. First, it suggests a broader range of factors to be considered as sources for isolating mechanisms. Extant studies on the causal factors creating isolating mechanisms focus largely on the intrinsic characteristics of knowledge such as tacitness, specificity, and/or complexity (Reed and Defillippi, 1990; Rivkin, 2000). This study shows that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms due largely to the two unique attributes of international markets: *a higher degree of market frictions* and *a higher degree of heterogeneity*. This finding suggests that different types of viable strategies can be employed to create isolating mechanisms and thus sustaining competitive advantages. As firms can be conceived of as a bundle of heterogeneous resources and capabilities (Amit and Schoemaker, 1993; Mahoney and Pandian, 1992), firms can and sometimes need to implement different types of strategy by allocating resources unique to the firm to create isolating mechanisms. On one hand, firms can rely on the intrinsic characteristics of their knowledge to create isolating mechanisms if a firm's knowledge is causally ambiguous and/or unique. On the other hand, it would also be feasible for the firm to create isolating mechanisms by acquiring knowledge from multiple countries. More fundamentally, however, the implications of this research study suggest that a firm can achieve the goal of creating isolating mechanisms by selecting a combination of causal factors that best fits its existing resources and capabilities. That is to say, even though a

firm is able to increase, for instance, the causal ambiguity or uniqueness from both intrinsic characteristics of knowledge and geographic scope, if the firm has better-developed international presence for knowledge acquisition, then it would be more efficient to create isolating mechanisms by emphasizing geographic scope as a source of causal ambiguity or uniqueness, while the opposite would also be true for a firm with limited international presence. In short, firms can develop strategies that utilize resources and capabilities available within their firms.

Second, this research study elucidates that geographic scope can be a source of both *value creation* and *value appropriation*. On this basis, this study suggests a new motivation of firm internationalization: *value appropriation* and thus *sustaining competitive advantage*.[22] Extending the extant studies on the role of geographic scope that largely focus on the value creation aspects, this study shows that geographic scope of knowledge acquisition can be a source of value appropriation by creating isolating mechanisms. From this perspective, the theoretical argument and empirical findings of this chapter suggests a new motivation of firm internationalization as a strategy to create isolating mechanisms, thus achieving and maintaining *sustainable* competitive advantage. Extant research literature on the motivations of firm internationalization emphasizes *exploitation* of firm-specific advantages (Dunning, 1988; Hymer, 1960/1976) and, recently, *exploration* or augmentation of strategic assets (Makino *et al.*, 2002; Moon and Roehl, 2001). In other words, the extant literature on the motivation of firm internationalization focuses on the exploitation of firm resources and capabilities (or ownership advantage) to explore or to seek resources and capabilities unavailable or preempted by competitors in domestic markets (e.g., natural-resource seeking, market seeking, efficiency-

[22] This research study takes a broad definition of firm internationalization as a process of acquiring knowledge from international markets via various governance structures, which encompasses all forms of the governance structures that are employed to acquire knowledge from international markets (including, but not limited to, merger and acquisition, strategic alliances, joint venture).

seeking, and strategic asset-seeking (Dunning, 1995; 2000)). While the extant international business literature focuses on *creating* competitive advantage via exploitation/exploration, this research study suggests a new motivation of firm internationalization by illuminating the role of geographic scope in *sustaining* the competitive advantage (Barney, 1991). In other words, the liability of foreignness (Hymer, 1960/1976; Teece, 1981b; Zaheer, 1995) or the liability of outsidership from relevant networks (Johanson and Vahlne, 2009) and country heterogeneity (Ricart *et al.*, 2004), when strategically utilized, can be sources of *sustainable* strategic rents (Foss and Foss, 2005; Peteraf, 1993). Therefore, firms can implement internationalization not only to *create* competitive advantage via exploitation/exploration but also to *sustain* the competitive advantage via isolating mechanisms from geographic scope. In sum, in addition to the established knowledge in the extant international business literature that focuses mostly on the exploitation, exploration, or 'seeking' aspects of the motivations of multinational corporations' (MNCs) investments, this research study suggests that firm internationalization to acquire knowledge from international markets can be a strategic option to *sustain* competitive advantage by leveraging the attributes of international markets that help an effective creation of isolating mechanisms.

Lastly, this research study suggests that studies employing the number of forward citations a patent receives or the number of patents weighted by the number of forward citations need to pay special attention to possible mediating effects of isolating mechanisms. By demonstrating the mediating effects of isolating mechanisms on the number of forward citations, this research study highlights that researchers need to pay attention to the multiple drivers leading to forward citations. The extant studies employing the number of forward citations as a proxy for innovation quality implicitly assume that firms can access innovative knowledge whenever they are *motivated* to. However, firms cannot access the knowledge even though they are motivated if

they are not *aware* of the source of the superior performance or they are not *capable* of transferring the knowledge (Hoetker and Agarwal, 2007). In this light, the current approach to the number of forward citations as a proxy for innovation quality misses a very important driver of forward citations, *isolating mechanisms*. Given the fact that causal ambiguity and uniqueness, the two major factors creating isolating mechanisms (Lippman and Rumelt, 1982), can be associated with awareness and capability of transferring knowledge, respectively, taking into account the implications of isolating mechanisms is critical to better understand the nature of forward citations.

This study has limitations, which provide avenues for future research. First, this research study views firm internationalization as a process of acquiring knowledge from international markets via various governance structures. But, as extant studies expound (Almeida, Song, and Grant, 2002; Kogut and Zander, 1993), we can expect that different types of governance structures for knowledge acquisition should have moderating effects on the relationship between isolating mechanisms and firm performance. Future studies explicitly addressing the possible moderating effects of governance structures could provide valuable insight on the nature of isolating mechanisms and firm performance. Second, future studies employing other than the time to first forward citation to operationalize isolating mechanisms could validate the arguments advanced in this study and further enrich our understanding.

FIGURES AND TABLES

Table 5.1: Hypotheses and Classification

Hypothesis	Relationship	Content	Classification	Mediation Notation*	Estimates of Parameters**
5.1	Geographic Scope and Innovation Quality	The greater the geographic scope in a patent's backward citations, the fewer the number of forward citations a patent receives.	Base-line Hypothesis for Mediating Effect	**X → Y**	$\hat{c}$
5.2a	Geographic Scope and Isolating Mechanisms	The greater the geographic scope in a patent's backward citations, the longer it takes for other firms to cite that patent.	*Mediating* Effect of Isolating Mechanisms	**X → M**	$\hat{a}$
5.2b	Isolating Mechanisms and Innovation Quality	The longer it takes for other firms to cite a patent, the fewer the number of forward citations a patent receives.	*Mediating* Effect of Isolating Mechanisms	**M → Y**	$\hat{b}$
5.2c	Mediating Effect of Isolating Mechanisms	The increase in time for other firms to cite a focal firm's patents would *partially* mediate the influences of the extent of geographic scope in a patent's backward citations on the number of forward citations a patent receives.	*Mediating* Effect of Isolating Mechanisms		$\hat{c}'$
5.3	Isolating Mechanism and Financial Performance	The longer it takes for other firms to cite a focal firm's patents, the more positive the effect of innovation quality on financial performance.	*Moderating* Effect of Isolating Mechanisms		

* Each of X, M, and Y denotes notations representing X: the independent variable; M: the mediating variable; and Y: the dependent variable.

** Each of the estimates of parameters represents $\hat{a}$: the parameter relating the independent variable and the mediator; $\hat{b}$: the parameter relating the mediator and the dependent variable; $\hat{c}$: the parameter relating the independent and the dependent variable *without* adjustment for the mediator effect; and $\hat{c}'$: the parameter relating the independent and the dependent variable *with* adjustment for the mediator effect (MacKinnon, 2008).

Table 5.2: (a) Descriptive Statistics and Correlation (patent level for Hypotheses 5.1-2)

	Variables	Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Number of Countries	2.34	1.12	1	11	1						
(2)	Time to First Forward Citation (in year)	2.02	1.27	1	11	0.00	1					
(3)	Originality	0.35	0.28	0	0.92	0.12	0.03	1				
(4)	Number of Claims	18.92	12.59	1	191	0.04	-0.05	0.06	1			
(5)	Number of International Patent Classes (IPC)	1.39	0.79	1	16	0.04	0.00	0.03	-0.02	1		
(6)	Number of Backward Citations	8.5	7.95	1	222	0.51	0.00	0.17	0.11	0.03	1	
(7)	Membership in Triadic Patent Families (TPF)	0.15	0.36	0	1	0.01	0.01	0.04	-0.02	0.02	0.03	1

Table 5.2: (b) Descriptive Statistics and Correlation (firm-year level for Hypothesis 5.3)

	Variables	Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1)	No of Forward Citations	8.09	5.71	0.5	33.63	1												
(2)	Time to First Forward Citation	2.17	0.59	1	5	-0.17	1											
(3)	Number of Countries	2.2	0.52	1	4.5	-0.05	-0.11	1										
(4)	Originality	0.39	0.13	0	0.84	0.11	-0.13	0.31	1									
(5)	No of Claims	17.6	5.77	7.14	41.22	-0.23	-0.05	0.39	0.16	1								
(6)	Number of International Patent Classes (IPC)	1.39	0.19	1	2.08	0.14	0.08	0.05	-0.13	-0.12	1							
(7)	Number of Backward Citations	13.53	16.26	1	119.57	0.20	-0.20	0.20	0.40	0.00	-0.06	1						
(8)	No of Patents	251.33	411.41	1	1586	-0.12	-0.12	0.10	-0.03	0.17	-0.02	-0.09	1					
(9)	ln(R&D Intensity)	0.11	0.07	0.01	0.51	0.07	-0.13	-0.08	0.08	0.03	-0.15	0.25	-0.19	1				
(10)	ln(Advertising Intensity)	0.01	0.01	0	0.06	0.32	-0.15	-0.24	-0.06	-0.16	0.07	0.10	0.26	0.16	1			
(11)	ln(Size)	6.75	2.23	1.88	10.78	-0.19	-0.04	0.05	-0.02	0.02	0.06	-0.24	0.67	-0.55	0.01	1		
(12)	Firm Leverage	0.09	0.11	0	0.57	-0.17	-0.05	0.35	-0.01	0.09	0.20	-0.08	0.15	0.11	-0.21	0.07	1	
(13)	Product Diversification	0.14	0.29	0	0.93	-0.18	0.05	-0.15	0.03	-0.31	0.09	-0.17	0.24	-0.37	-0.08	0.51	-0.09	1

Table 5.3: Negative Binomial and Accelerated Failure-Time Regression Results for Hypotheses 1~2

Models	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Hypotheses and Expected Signs	Hypothesis 5.1 (-)	Hypothesis 5.2a (+)	Hypothesis 5.2b (-)	Hypothesis 5.2c
Regressions	Negative Binomial	Accelerated Failure-Time	Negative Binomial	Negative Binomial
Dependent Variables	No of Forward Citations	Time to First Forward Citation	No of Forward Citations	No of Forward Citations
Mediation Notations	**X→Y**	**X→M**	**M→Y**	
Estimates of Parameter	$\hat{c}$	$\hat{a}$	$\hat{b}$	$\hat{c}'$
Independent Variable (X)				
Number of Countries	-0.0391*	0.00992**		-0.0307*
	(0.025)	(0.002)		(0.016)
Mediating Variable (M)				
Time to First Forward Citation (Isolating Mechanisms)			-0.480***	-0.480***
			(0.000)	(0.000)
Control Variables				
Originality	-0.113*	0.0714***	-0.0582	-0.0561
	(0.013)	(0.000)	(0.138)	(0.140)
Number of claims	0.0102***	-0.00179***	0.00923***	0.00913***
	(0.000)	(0.000)	(0.000)	(0.000)
Number of International Patent Classes (IPC)	0.0247*	-0.00460	0.0240†	0.0248†
	(0.034)	(0.212)	(0.058)	(0.053)
Number of Backward Citations	0.0104***	-0.000729	0.00823***	0.0105***
	(0.000)	(0.115)	(0.000)	(0.000)
Membership in Triadic Patent Families (TPF)		-0.0342***		
		(0.000)		
Year Dummies	Included	Included	Included	Included
Constant	2.225***	1.040***	3.140***	3.184***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	33,204	33,204	33,204	33,204
Chi-squared	783.0	1,486	8,408	9,184
Log-(pseudo)likelihood	-103,088	-30,118	-97,755	-97,735

p-values in parentheses; *** $p<0.001$, ** $p<0.01$, * $p<0.05$, † $p<0.1$;

• Each of X, M, and Y denotes notations representing X: the independent variable; M: the mediating variable; and Y: the dependent variable.

• Each of the estimates of parameters represents $\hat{a}$: the parameter relating the independent variable and the mediator; $\hat{b}$: the parameter relating the mediator and the dependent variable; $\hat{c}$: the parameter relating the independent and the dependent variable *without* adjustment for the mediator effect; and $\hat{c}'$: the parameter relating the independent and the dependent variable *with* adjustment for the mediator effect (MacKinnon, 2008).

Table 5.4: Estimation of Mediation Effects

Types	Effects	95% Quasi-Bayesian Confidence Intervals	
		Lower Bound	Upper Bound
Mediation Effect	-0.003904	-0.00661	-0.00116
Direct Effect	-0.0298	-0.03989	-0.02074
Total Effect	-0.0337	-0.04329	-0.02262
Proportion of Total Effect via Mediation	0.1202	0.03476	0.19446

Note: Confidence intervals are calculated using heteroskedasticity-consistent standard errors; Sample size used: 33,204

Table 5.5: Random-Effect Panel Regression Results for Hypothesis 5.3

Dependent Variable	ln(ROA)		
Models	**Model 1**	**Model 2**	**Model 3**
Independent Variable			
No of Forward Citations		0.00151	-0.0124*
		(0.477)	(0.022)
Moderating Variable			
Time to First Forward Citation		-0.000787	-0.0232
		(0.960)	(0.176)
Interaction Variable			
No of Forward Citations			0.00920**
× Time to First Forward Citation			(0.006)
Control Variables			
Number of Countries	0.0350†	0.0356†	0.0364†
	(0.086)	(0.089)	(0.072)
Originality	-0.0493	-0.0575	-0.0100
	(0.473)	(0.434)	(0.891)
No of Claims	0.000607	0.000728	0.00150
	(0.770)	(0.738)	(0.478)
Number of International Patent Classes	0.0241	0.0235	0.0153
	(0.634)	(0.651)	(0.760)
Number of Backward Citations	0.000565	0.000590	0.000631
	(0.315)	(0.309)	(0.259)
No of Patents	-0.000113**	-0.000105*	-9.51e-05*
	(0.004)	(0.012)	(0.019)
ln(R&D Intensity)	-0.0287	-0.0310	-0.124
	(0.915)	(0.909)	(0.639)
ln(Advertising Intensity)	1.997	1.807	1.870
	(0.107)	(0.163)	(0.135)
ln(Size)	0.0104	0.0104	0.00473
	(0.498)	(0.494)	(0.750)
Firm Leverage	-0.0229	-0.0424	-0.0674
	(0.801)	(0.652)	(0.459)
Product Diversification	0.0255	0.0314	0.0239
	(0.677)	(0.620)	(0.696)
Year Dummies	Included	Included	Included
Constant	-0.0767	-0.0871	-0.0716
	(0.572)	(0.541)	(0.603)
Observations	117	117	117
R^2 (within)	0.514	0.512	0.563
R^2 (between)	0.0461	0.0649	0.107
Chi-square	58.35	55.49	67.35

p-values in parentheses; *** $p<0.001$, ** $p<0.01$, * $p<0.05$, † $p<0.1$

Table 5.6: Random-Effect Panel Regression Results for Hypothesis 5.3 (robustness checks)

Dependent Variables	ln(RORD)			ln(net profit margin)		
Models	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Independent Variable						
No of Forward Citations		0.0162	-0.116***		0.00193	-0.0122*
		(0.175)	(0.000)		(0.376)	(0.032)
Moderating Variable						
Time to First Forward Citation		0.00645	-0.219*		0.00420	-0.0188
		(0.948)	(0.040)		(0.796)	(0.300)
Interaction Variable						
No of Forward Citations			0.0806***			0.00925**
× Time to First Forward Citation			(0.000)			(0.007)
Control Variables						
Number of Countries	0.155	0.150	0.145	0.0312	0.0316	0.0320
	(0.186)	(0.203)	(0.179)	(0.137)	(0.141)	(0.127)
Originality	-0.580	-0.702†	-0.395	-0.0552	-0.0703	-0.0268
	(0.153)	(0.093)	(0.313)	(0.436)	(0.352)	(0.724)
No of Claims	0.000155	0.00199	0.00597	0.000925	0.00118	0.00196
	(0.989)	(0.863)	(0.570)	(0.665)	(0.596)	(0.372)
Number of International Patent Classes	0.352	0.340	0.136	0.0108	0.00867	-0.00219
	(0.217)	(0.233)	(0.611)	(0.836)	(0.870)	(0.966)
Number of Backward Citations	0.00341	0.00333	0.00242	0.000614	0.000639	0.000673
	(0.342)	(0.350)	(0.465)	(0.293)	(0.287)	(0.253)
No of Patents	-0.000463*	-0.000453*	-0.000495*	-0.000126**	-0.000118**	-0.000109**
	(0.031)	(0.036)	(0.012)	(0.002)	(0.006)	(0.009)
ln(R&D Intensity)	-1.873†	-1.753	-1.583	0.160	0.171	0.0983
	(0.078)	(0.106)	(0.105)	(0.546)	(0.522)	(0.704)
ln(Advertising Intensity)	5.266	4.114	8.189†	1.604	1.382	1.510
	(0.311)	(0.450)	(0.097)	(0.197)	(0.285)	(0.229)
ln(Size)	0.0387	0.0375	0.0277	0.0249†	0.0239†	0.0188
	(0.432)	(0.457)	(0.532)	(0.087)	(0.097)	(0.177)
Firm Leverage	-0.951†	-0.921†	-1.168*	-0.0881	-0.108	-0.141
	(0.066)	(0.075)	(0.014)	(0.347)	(0.261)	(0.137)
Product Diversification	0.189	0.259	0.256	0.0215	0.0281	0.0207
	(0.544)	(0.416)	(0.367)	(0.733)	(0.665)	(0.745)
Year Dummies	Included	Included	Included	Included	Included	Included
Constant	0.0117	-0.140	0.0964	-0.144	-0.164	-0.147
	(0.984)	(0.837)	(0.878)	(0.280)	(0.244)	(0.284)
Observations	117	117	117	117	117	117
R^2 (within)	0.522	0.538	0.584	0.533	0.534	0.576
R^2 (between)	0.281	0.281	0.462	0.0485	0.0623	0.115
Chi-square	71.60	75.30	104.9	63.71	61.08	70.47

p-values in parentheses; *** $p<0.001$, ** $p<0.01$, * $p<0.05$, † $p<0.1$

Figure 5.1: Conceptual Model

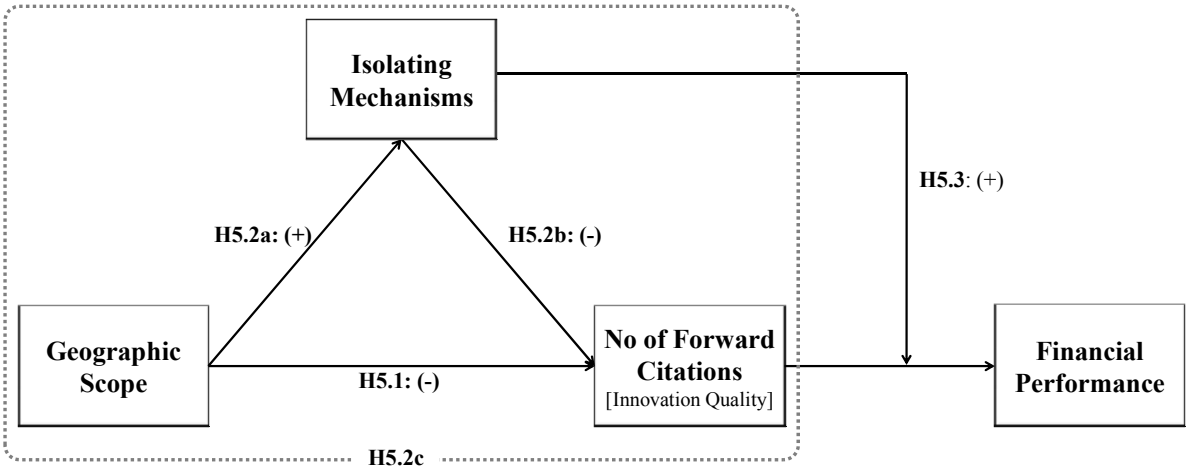


Figure 5.2: Graphical Summary of Mediation Effects

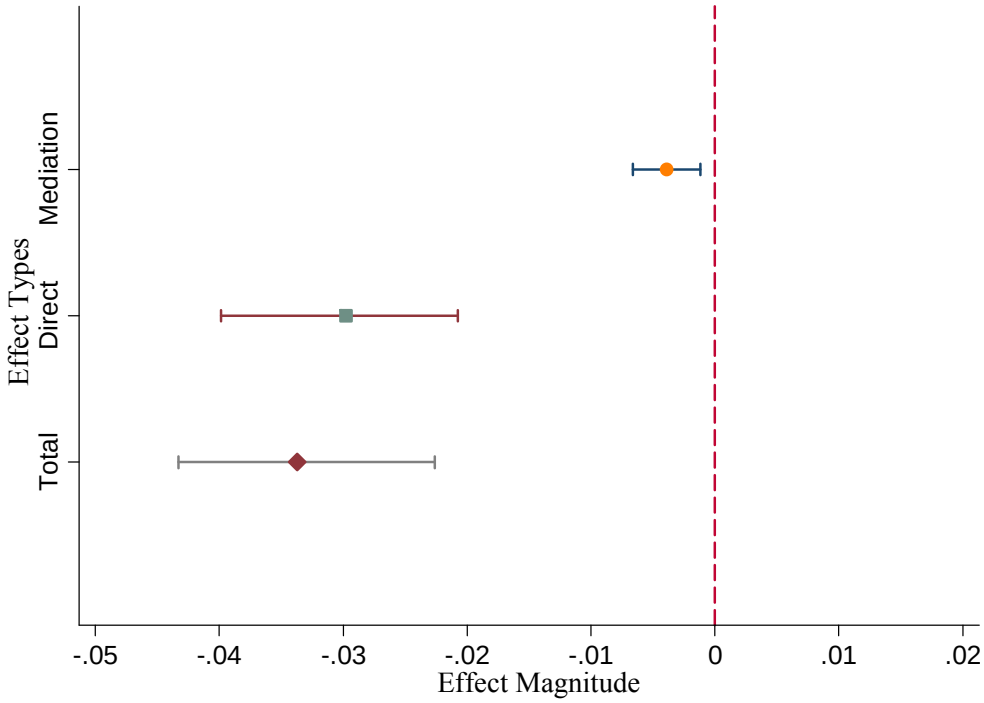
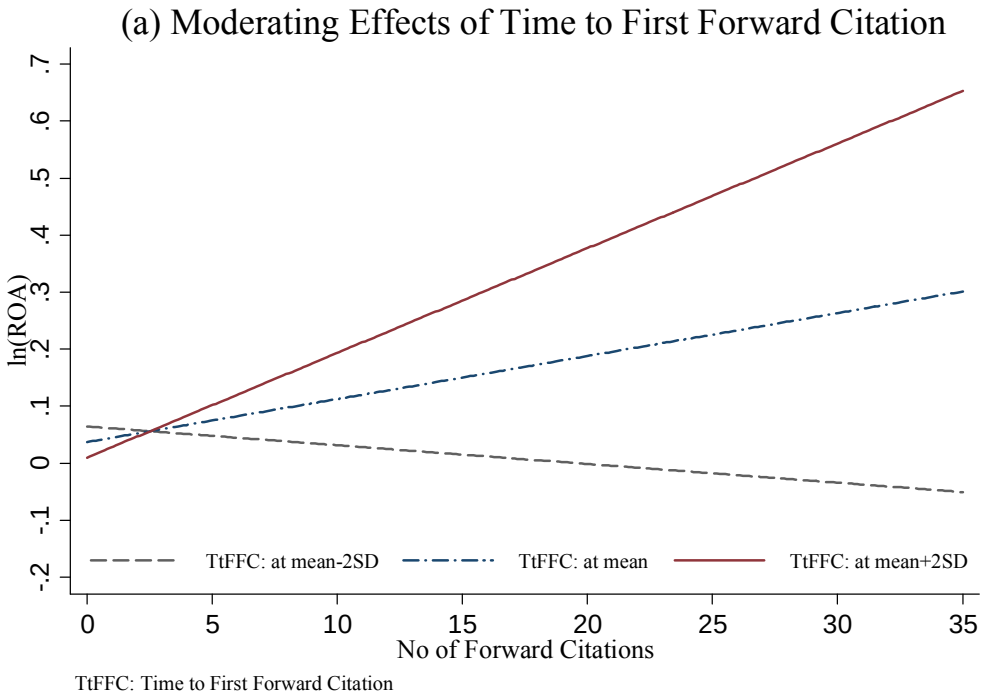


Figure 5.3: Moderating Effects of Isolating Mechanisms on the Relationship between Innovation Quality and Financial Performance



TtFFC: Time to First Forward Citation

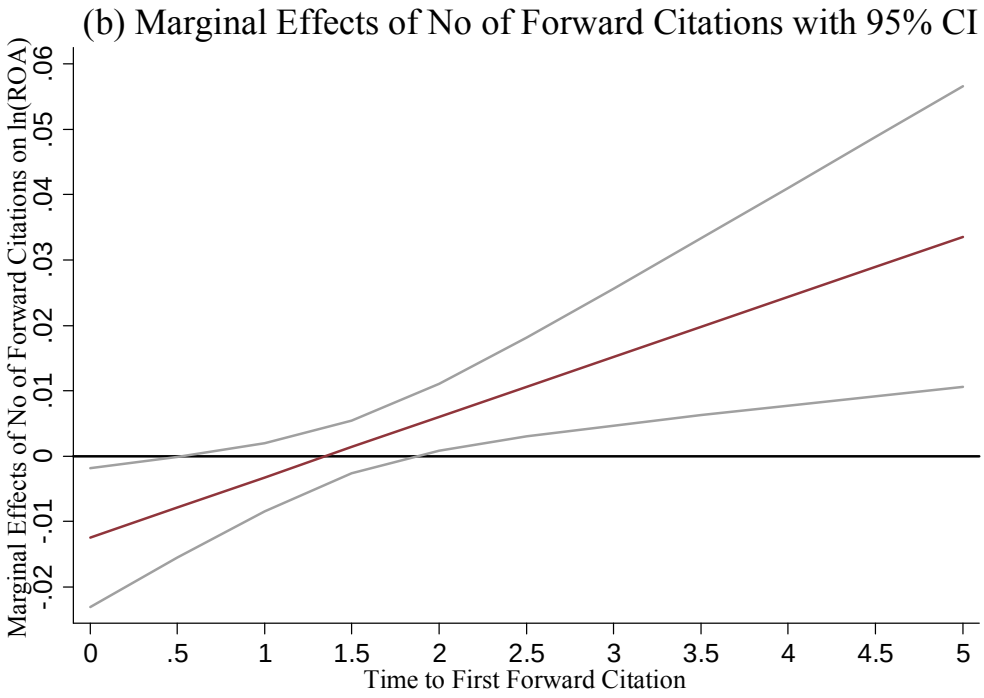
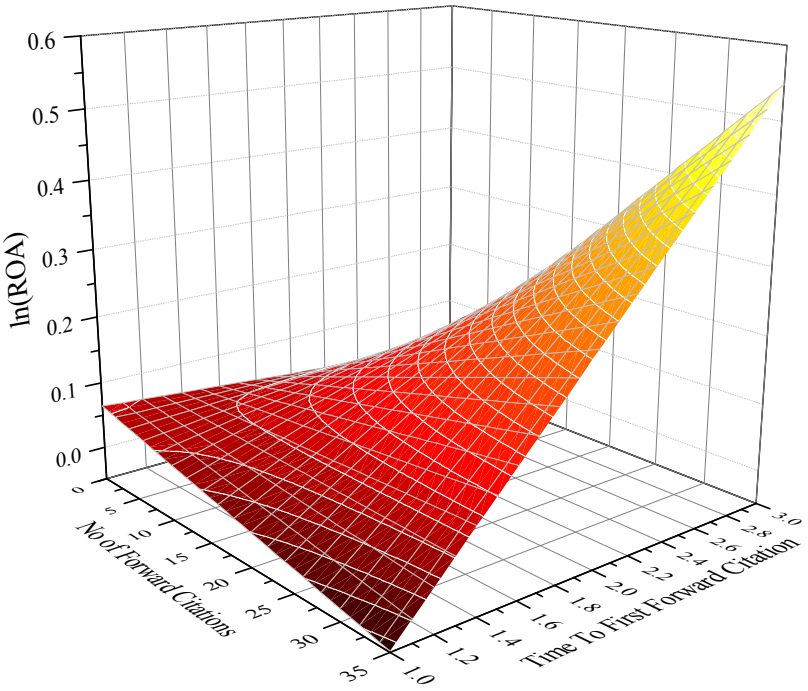
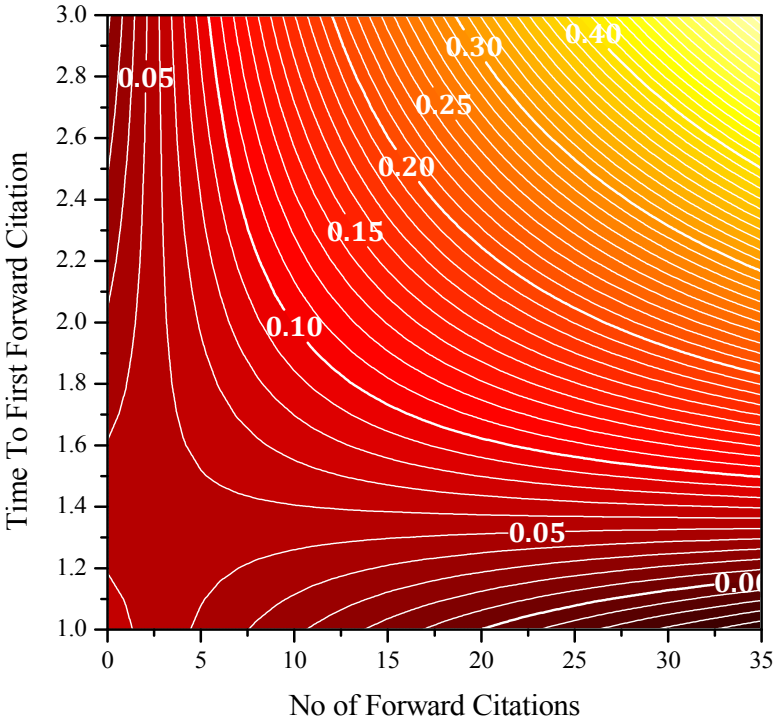


Figure 5.4: 3-dimensional Illustration of the Moderating Effects of Isolating Mechanisms

(a) 3-Dimensional Graph



(b) Contour Graph



CHAPTER 6: DISCUSSION AND CONCLUSION

This dissertation examines antecedents and consequences of isolating mechanisms. Focusing on the geographic scope of knowledge acquisition, I address the four questions on the *sources* of the isolating mechanisms, the *relationship* among the causal factors creating isolating mechanisms, and their performance implications. In Chapter 3, I investigate the first question whether geographic scope of knowledge acquisition can be an independent source of isolating mechanisms, in addition to the intrinsic characteristics of knowledge. I maintain that, *independently from* and *jointly with* the intrinsic characteristics of knowledge, geographic scope can create isolating mechanisms. In Chapter 4, I study the relationship among the causal factors creating isolating mechanisms from the two different sources: *intrinsic characteristics* and *geographic scope*. I submit that the combinations of causal factors provide multiple paths leading to creation of isolating mechanisms (i.e., equifinality) and that, in these paths, the causal factors from the two different sources can play similar roles (i.e., functional equivalence). Chapter 5 addresses the remaining two questions on the performance implications of isolating mechanisms, focusing on the value appropriation aspects of geographic scope of knowledge acquisition. I maintain that geographic scope of knowledge acquisition, as advanced in Chapter 3, can create isolating mechanisms and, therefore, not only creates innovative knowledge but also impedes the flow of knowledge, preventing other firms from accessing the innovative knowledge. This would in turn enable a firm to enjoy a longer period of time to more exclusively capture the economic return from innovation, thus helping the firm achieve better financial performance from given innovation outputs. These points highlight that geographic scope of knowledge acquisition can be a source of value appropriation by creating isolating mechanisms, and firms can enjoy better

financial performance by implementing appropriate strategies for acquiring knowledge in international markets.

Chapters in this dissertation are organized to highlight and derive further implications from the main theses advanced in each chapter. First, Chapters 3 and 4 (i.e., Questions 1 and 2) are contrasted with Chapter 5 (i.e., Questions 3 and 4) as the *antecedents* and *consequences* in order to provide a systemic framework of isolating mechanisms. This structure allows us to have a holistic understanding of the process through which geographic scope of knowledge acquisition can create isolating mechanisms *independently from* and *jointly with* intrinsic characteristics of knowledge and the its consequent performance implications.

Second, I contrast Chapter 3 and Chapter 4 to highlight the need for different methodologies to address different questions. Regression models are ideal to examine the marginal effects of independent causal factors, while the fuzzy-set QCA approach is more suitable to investigate the conjunctural and configurational nature of causal factors. When appropriately employed, these two different types of methodologies answer different questions on the same phenomenon, enriching our understanding of the phenomenon.

Third, I integrate Questions 3 and 4 in a single chapter (i.e., Chapter 5) to more effectively illustrate the process of value appropriation. Question 3 highlights the prerequisite of value appropriation articulated by Foss and Foss that "value appropriation presupposes that the owner can *exclude* non-owners from using or destroying attributes to which he holds property right" (Foss and Foss, 2005: 544). Question 4 illuminates the financial performance implications of the exclusion. By excluding other firms from accessing the innovative knowledge, firms can enjoy a longer period of time to more exclusively capture the economic returns from innovation, which allows the firms to achieve better financial performance. In this way, the two questions in Chapter 5 together illustrate the process of value appropriation.

The design of this dissertation also attempts to achieve theoretical pluralism and methodological triangulation (Azevedo, 1997, 2002; Van de Ven, 2007). When developing theoretical frameworks to show that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms, Chapter 3 and 4 draw mostly from the social network theoretical perspectives, while Chapter 5 jointly from the resource-based view and the transaction costs theory. These multiple theories indeed predict the same causal relationship between geographic scope of knowledge acquisition and isolating mechanisms. In addition, this dissertation also attempts to achieve the methodological triangulation by employing different empirical settings to test the same hypothesis that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms (Azevedo, 1997). More specifically, Chapters 3 and 4 employ patent data filed at EPO while Chapter 5 utilizes patent data filed at USPTO. Although different in empirical contexts, results of empirical analyses reported in Table 3.2 and Model 2 of Table 5.3 corroborate that geographic scope of knowledge acquisition can be an independent source of isolating mechanisms. In this way, the theoretical pluralism and methodological triangulation enhance validity, generalizability, and robustness of the main thesis and the empirical findings of this dissertation (Azevedo, 1997; Van de Ven, 2007).

This dissertation contributes to management literature at least in four ways. First, it highlights that the causal factors creating isolating mechanisms come from different sources but at the same time work together in multiple combinations. It shows that geographic scope of knowledge acquisition can be *an independent source* of isolating mechanisms in addition to intrinsic characteristics of knowledge and that different configurations of causal factors can achieve the same goal of creating isolating mechanisms. Therefore, we need to consider a broader range of factors as the sources of isolating mechanisms and multiple ways of combining them. This point provides critical strategic implications. When considering a firm as a

heterogeneous bundle of resources and capabilities (Amit and Schoemaker, 1993), we can expect that each firm is equipped with resources and capabilities different from other firms. The findings of this dissertation suggest that firms can achieve the same goal of creating isolating mechanism and sustaining competitive advantage by implementing different types of viable strategies utilizing different combinations of the causal factors that fit best to a focal firm's existing resources and capabilities. Indeed, many roads lead to Rome and it is the role of the managers to figure out the best road for their firms.

Second, it shows that geographic scope of knowledge acquisition has dual aspects: a source of both *value creation* and *value appropriation*. On the one hand, a broader geographic scope of knowledge acquisition provides more heterogeneous knowledge, which would in turn allow firms to have more unique combinations and thus more innovative knowledge. On the other hand, as advanced in Chapter 3, it can also create isolating mechanisms around a firm's innovation knowledge and thus help a firm sustain its competitive advantage by preventing competitors from accessing its knowledge. Therefore, by using geographic scope strategically, a firm can *create* and at the same time *appropriate* economic returns from innovation as advanced in Chapter 5. This implies that firms not only *create* but also *sustain* their competitive advantage utilizing their geographic scope of knowledge acquisition.

Third, it suggests a new motivation of firm internationalization. The existing literature maintains that firms internationalize largely to create value by either exploiting firm-specific advantages in international markets (Dunning, 1988; Hymer, 1960/1976) or seeking new strategic resources in those markets (Makino *et al.*, 2002; Moon and Roehl, 2001). This dissertation extends the extant literature that focuses largely on *creating* competitive advantage and suggests that internationalization, specifically knowledge acquisition from international

markets, can help *sustain* competitive advantage by leveraging the unique attributes of international markets to create isolation mechanisms.

Lastly, this research study also contributes to identifying and addressing methodological issues. It shows that studies employing forward-citation-based measures need to pay special attention to the nature of the measurement. In fact, the forward-citation-based measures rely on the implicit assumption that firms can access whatever knowledge they are *motivated* to. However, it is of critical importance to notice that firms cannot access the innovative knowledge if isolating mechanisms impede the flow of knowledge in such a way that they are not *aware* of the sources of superior performance or, even if they are aware of the sources, they are not *capable* of transferring the knowledge (Chen, 1996; Chen *et al.*, 2007). Therefore, studies employing the number of forward citations or the number of patents weighted by the number of forward citations should pay attention to possible mediating effects of isolating mechanisms and appropriately control for these effects.

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